

April 2016

Optimizing Client Scheduling and Improving Client Distribution for Fundación Paraguaya

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Optimizing Client Scheduling and Improving Client Distribution for Fundación Paraguaya

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Fundación Paraguaya

April 28th, 2016

A Major Qualifying Project submitted to the faculty of

Worcester Polytechnic Institute

In partial fulfillment of the requirements for the

Degree of Bachelor of Science

Abstract

The goal of our project was to improve the efficiency of Fundación Paraguaya's Microfinance and Poverty Stoplight Programs by implementing Industrial Engineering techniques. First, we addressed inefficient planning of client meetings through an Excel-based scheduling tool that optimally groups geographically similar meetings. Based on our results, the scheduling tool has the potential to reduce 19.92% of the total distance traveled. Second, we developed a tool to analyze the rezoning of offices by evaluating the impact of the corresponding reassignment of client committees to their respective zones. If all reassignments are made, the total distance reduction will exceed 2,400 miles. Our two deliverables will be implemented upon completion of the project.

Acknowledgements

We would like to thank the entire team of Fundación Paraguaya for their continuous dedication and support during the completion of our project. We specifically would like to acknowledge the following people:

Martin Burt - Executive Director of Fundación Paraguaya

Lourdes Agüero – Poverty Stoplight Manager for Governments and Enterprises

Nancy Ramos – Poverty Stoplight Manager for Civil Society

Omar Sanabria - Microfinance Program Manager

We would also like to acknowledge our three advisors, Professor Peter Hansen (Ph.D.), Professor Andrew Trapp (Ph.D.), and Professor Karla Mendoza Abarca (Ph.D.) for all their guidance and support. Special thanks to Professor Andrew Trapp for traveling to Paraguay with us.

Authorship

The two students listed on the cover of this report contributed equally to its content and revision.

Table of Contents

| | |
|---|-------------|
| Abstract..... | ii |
| Acknowledgements | iii |
| Authorship | iv |
| List of Figures..... | vii |
| List of Tables | viii |
| 1. Introduction..... | 1 |
| 2. Background | 3 |
| 2.1 Introduction to Paraguay | 3 |
| 2.2 Overview of our Sponsor, Fundación Paraguaya | 3 |
| 2.3 Microfinance..... | 4 |
| 2.3.1 History of microfinance..... | 4 |
| 2.3.2 The Microfinance System..... | 5 |
| 2.3.3 Microfinance Program in Fundación Paraguaya | 5 |
| 2.4 Challenges Faced by Fundación Paraguaya | 6 |
| 2.4.1 Research Conducted Concerning Challenges of Fundación Paraguaya's Administration | 6 |
| 2.4.2 Individual Challenge: Lack of Planning by Asesores | 7 |
| 2.4.3 Organizational Challenge: Zoning Inefficiency | 7 |
| 2.5 Optimization | 7 |
| 2.5.1. Clustering..... | 9 |
| 3. Methodology | 10 |
| 3.1 Understand the Operations of Fundación Paraguaya's Microfinance and Poverty Stoplight Programs and Identify Challenges and Areas of Improvement..... | 10 |
| 3.1.1 Visit to Fundación Paraguaya..... | 10 |
| 3.1.2 Interviews | 11 |
| 3.1.3 Shadowing an Asesor | 12 |
| 3.2 Evaluate the Challenges and Design Potential Solutions that Apply Industrial Engineering Techniques | 12 |
| 3.3 Develop Two Solutions that Improve the Efficiency of the Microfinance Program and the Poverty Stoplight Program and Make an Implementation Plan..... | 13 |
| 3.3.1 Optimization of Scheduling Process..... | 13 |
| 3.3.2 Redistribution of the Microfinance Program's Client Committees..... | 19 |
| 4. Results | 22 |
| 4.1 Understand the Operations of Fundación Paraguaya's Microfinance and Poverty Stoplight Programs and Identify Challenges and Areas of Improvement..... | 22 |
| 4.1.1 Visit to Fundación Paraguaya..... | 22 |
| 4.1.2 Interviews | 23 |
| 4.1.3 Shadowing an Asesor | 26 |

| | |
|--|-----------|
| 4.2. Evaluate Existing Challenges and Determine Solutions | 27 |
| 4.3 Solutions that improve the efficiency of the Microfinance and the Poverty Stoplight programs and Implementation Plans | 29 |
| 4.3.1 Optimization of Scheduling Process..... | 29 |
| 4.3.2 Redistribution of FP's Microfinance Program's Committees | 36 |
| 5. Conclusions..... | 45 |
| 6. Reflections..... | 47 |
| Bibliography:..... | 50 |
| Appendix A: Modifications Made to Model (1.1)-(1.6) to Achieve Linearity..... | 53 |
| Appendix B: Visual Basic for Applications Code | 54 |
| Scheduling Tool Model Code | 54 |
| Code that Checks for Errors Before Creating the Model | 77 |
| Macros Used by the Tool | 81 |
| Code Used in all Userforms | 84 |
| Userform Used to Determine the Maximum Amount of Meetings per Day | 84 |
| Userform Used to Determine the Maximum Total Meeting Time per Day | 87 |
| Userform Used to Determine the Minimum Amount of Meetings per Day..... | 88 |
| Userform Used to Add Clients Manually | 91 |
| Appendix C: Records of Schedules Followed by Asesores..... | 93 |

List of Figures

| | |
|--|----|
| Figure 1: The Decision Making Process adapted from (Newton, 2007) | 8 |
| Figure 2: Project Objectives..... | 10 |
| Figure 3: Visual Example of how M [^] c works and Coordinates Used to Create Graph. | 18 |
| Figure 4: Zones determined by FP Officers for Each Office..... | 19 |
| Figure 5: Ray Casting Method Functionality (Songa, 2014)..... | 20 |
| Figure 6: Hierarchical Structure of the Microfinance Program | 23 |
| Figure 7: Summary of Asesores Meetings and Activities | 24 |
| Figure 8: Breakdown of Activities during Committee Visit..... | 27 |
| Figure 9: Challenges Addressed during our Project | 28 |
| Figure 10: New Scheduling Process | 29 |
| Figure 11: Selected Clients Tab..... | 31 |
| Figure 12: Database Tab | 32 |
| Figure 13: Settings Tab | 33 |
| Figure 14: Proposed Schedule | 33 |
| Figure 15: Schedule of an Asesor in Luque and Schedule of Luque's Asesor Made with the Tool | 35 |
| Figure 16: List of all Client Committees Included in the Analysis | 37 |
| Figure 17: From/To Chart of Client Committees that Moved to another Office..... | 38 |
| Figure 18: From/To Chart of Loan Amounts Pertaining to Client Committees that Moved to Another Office | 40 |
| Figure 19: Example of Summary Report of Reassignment of Client Committees for an Office . | 43 |

List of Tables

| | |
|--|----|
| Table 1: Example of an Asesor's Monthly Meetings | 25 |
| Table 2: Possible Errors and their Message Boxes | 34 |
| Table 3: Comparison between Asesores' Schedule and our Tool's Schedule | 35 |
| Table 4: Summary of From/To Chart for Client Committees that Moved to Another Office..... | 39 |
| Table 5: Summary of From/To Chart of Loan Amounts Pertaining to Client Committees that Moved to another Office..... | 41 |
| Table 6: Total Amount of Committees and Loans Analyzed | 42 |
| Table 7: Summary of Analysis of Reassignment of Client Committees | 42 |

1. Introduction

A key study on the cross-country differences in the non-profit sector size identified that 4.75% of the global workforce is dedicated to the nonprofit sector. The study focused on 38 countries that represented a varied selection due to the combination of developed and non-developed countries (Pevcin 2012). The nonprofit sector has experienced substantial growth in recent decades due to poor socio-economic conditions and government inefficiencies (Mendoza-Abarca and Anokhin 2013). Nonprofit and humanitarian sectors represent a vast potential for operations research, a method used to help make executive decisions regarding operations in any field by providing quantitative data. Although this field is commonly associated to applications with commercial and industrial sectors, the interest from researchers and practitioners to apply it to nonprofit and humanitarian sectors has risen due to the unique opportunity to address problems “whose solutions would contribute to meet social and global needs” (Maya 2012).

Humanitarian applications of operations research have primarily been focused on disaster relief. Some, however, have used operations research to tackle problems found in the day-to-day operations of non-profit organizations (NPOs). The dissertation work of Pablo Maya, used optimization methods to help two NPOs improve their efficiency, and also developed algorithms that could potentially be used for other humanitarian-related challenges. His research helped assign and route Teacher Assistants for disabled students in Belgium and plan for the delivery of home care services for the Landelijke Thuiszorg organization. As a result, the NPOs realized the impact optimization could have on their operations, as they could increase their service levels and decrease transportation costs (Maya 2012).

Fundación Paraguaya (FP), an NPO based in Paraguay that works towards poverty alleviation, represents an opportunity for an operations research project. FP was founded in 1985 in Asuncion, Paraguay, and currently has 28 offices around the country. The organization has developed five main programs: a microfinance program, an entrepreneurial and financial educational program for children and youth, self-sustainable agricultural high-schools, the Poverty Stoplight, and TeachAManToFish (Fundación Paraguaya, n.d.-a). The microfinance program started because leaders of FP learned from Mohamad Yunus' microfinance institution (MFI) the impact relatively small loans could have in incentivizing business growth and alleviating poverty (Fundación Paraguaya, n.d.-b). Currently, FP provides financial services to approximately 60,000 low income individuals through their microfinance program (Cite Omar).

FP aims to "strengthen the microfinance program and increase the total number of client committees by at least 2.5 times before 2017" (Fundación Paraguaya, n.d.-a). In order to achieve this goal, FP needs to overcome identified challenges in their day-to-day operations such as lack of organization from their microfinance officers (asesores) and zoning inefficiency of their offices and

workers (Fundación Paraguaya, 2015). These challenges were found through research conducted by FP human resources trainers and confirmed during our interviews in our trip to Paraguay early January 2016. During our trip, we were able to assess those challenges, brainstorm potential solutions, and verify if the solutions would work for FP. Fundación Paraguaya is actively looking for new and innovative approaches to solve their challenges. FP's research confirms the need for flexible tools that help them address their challenges without disrupting the culture and working style of the organization.

Our project intends to assist FP accomplish their goals and overcome their challenges through industrial engineering methods. We intend to aid Fundación Paraguaya in improving the efficiency of its Microfinance and Poverty Stoplight programs. In order to achieve this goal, our team set the following related objectives:

1. Understand the operations of the microfinance and Poverty Stoplight programs to identify challenges and areas of improvement.
2. Evaluate the challenges to design potential solutions that apply Industrial Engineering techniques.
3. Develop two solutions that improve the efficiency of the programs and make implementation plans.

In continuation of this report, Chapter 2 presents background research that includes the context of our project. Chapter 3 discusses the methods used to achieve our objectives and describes our two main deliverables. Chapter 4 presents the results and analysis of our methods. Finally, Chapter 5 describes our conclusions, impact of our deliverables, and future recommendations.

2. Background

2.1 Introduction to Paraguay

Paraguay is a landlocked country located in Central South America. The Paraguay River flows through the country and divides it into two different areas: the forest on the east and the plains on the west (National Geographic 2005). The population in Paraguay is approximately 7 million, of which 2.5 million live in the capital, Asunción. The official languages are Spanish and Guaraní (Central Intelligence Agency 2013). Many countries in Central and South America were colonized by Spain such as Venezuela, Mexico, Ecuador, and Paraguay. Paraguay, however, has a very different history from the others. The nation did not experience the slavery system that Spain implemented in other countries, such as Mexico and Peru, because it lacked precious ores such as gold or silver. Therefore, this characteristic was a blessing for the nation as the colonization process was more humane in Paraguay than in any other nation in South and Central America (Hanratty and Meditz 1988).

After three-hundred years of Spanish rule, along with frequent conflicts with Argentina, Bolivia, and Brazil, and unstable governments, most people in Paraguay were uneducated, unaware of the world, and lacked experience of a democratic environment (Hanratty and Meditz 1988). These times of instability delayed development in Paraguay. Moreover, between 1998 and 2002, the country went through a deep economic recession and poverty rates rose from 32% to 41%. Due to deficiencies in the government's planning, poverty alleviation programs had not been successful. These attempts had focused solely on telecommunications, livestock and mechanized farming instead of poor communities (Steele, Fernando, and Weddikkara 2008).

According to the market failure perspective, it is common for NPOs to emerge with the purpose of addressing social issues that current governments and markets have not been successful in targeting. Poor socioeconomic conditions and government inefficiency produce an increase in the creation of NPOs (Mendoza-Abarca and Anokhin 2013). Similarly, NPOs in Paraguay have taken on the task to try to alleviate poverty in the nation with effective programs without governmental barriers such as bureaucracy and corruption.

2.2 Overview of our Sponsor, Fundación Paraguaya

Fundación Paraguaya (FP) is an NPO that has worked towards poverty alleviation since 1985. Martin Burt, FP's founder and CEO, has served in various governmental roles, such as Mayor of Asunción, Vice Minister of Commerce, and Chief of Staff to the President of Paraguay (Fundación Paraguaya, n.d.-a). Burt founded FP in 1985 envisioning Paraguay to become "entrepreneurial and poverty-free, an example to the world" (Fundación Paraguaya, n.d.-a). FP's mission is to develop and

implement practical, innovative, and sustainable solutions to eliminate poverty and create decent living conditions for every family (Fundación Paraguaya, n.d.-a).

FP has 28 offices and staffs 450 employees around the country. The organization has focused on five main programs: a microfinance program, an entrepreneurial and financial educational program for children and youth, self-sustainable agricultural high-schools, the Poverty Stoplight, and TeachAManToFish. The organization started working in microfinance in 1985 when Martin and other leaders of FP learned that access to a relatively small loan given to a low-income individual could make a difference and incentivize business growth and poverty alleviation (Fundación Paraguaya, n.d.-a).

FP's main goals to accomplish by the end of 2017 to "strengthen the microfinance program and increase the total number of client committees served by at least 2.5 times". One of their main objectives is to optimize the use of resources in order to increase efficiency of the work conducted. In this manner, they can reach the greatest possible number of people represented in their target population. In addition, FP considers themselves an innovative organization that seeks to apply updated methodologies and technologies to solve worldwide issues (Fundación Paraguaya, n.d.-a). Our project intends to assist FP accomplish this objective by implementing technologies to improve the organization and effectiveness of the asesores in the microfinance program.

2.3 Microfinance

Nearly three billion people have little or no access to financial services (Murray 2010). Microfinance loans are a solution for low-income individuals and communities that find themselves excluded from banking, savings, and credit arrangements (Castree, Kitchen, and Rogers 2013). It is a commonly used approach to alleviate poverty as it offers small loans with no collateral requirement to the poor in both developing and developed countries (Sengupta and Aubuchon, Craig 2008). This service helps poor individuals become entrepreneurs, have a better nutrition, improve their living condition, and provide health benefits and education for their children.

2.3.1 History of microfinance

Microfinance dates back to the 18th century where it was used as a strategy to alleviate poverty. During the 1720s, the Irish Loan Funds emerged, and provided small loans with peer mentoring to enforce the weekly repayments. This is considered an early version of what microfinance is today (Hans Dieter 2003). In 1974, Dr. Mohammad Yunus, a professor from Bangladesh, pioneered modern day microfinance during an action research project near Chittatong University in Bangladesh. The research aimed to test that if the poor were provided with working capital, they could become self-employed without depending on external assistance. Yunus found women in Jabra, a small village in Bangladesh, who were selling their products and making a profit of two cents. The women, who had no money to buy raw materials, borrowed from middlemen, who gave them money with the condition of selling the

finished product back to them at a price they specified. Yunus realized that if there was a system that lent individuals small loans to sell their products at the price they wanted, the individuals could make more profit. As a result, he began to loan small amounts of money (about \$27) to 42 women that sold their own products. He realized small loans could motivate borrowers to get themselves out of poverty. In 1983, his project evolved into the Grameen Bank, a formal and independent financial institution. The Grameen Bank objectives were to eliminate the exploitation by money lenders, and create opportunities for self-employment in an area where manpower resources were under-utilized (Alam and Getubig 2010). Since then, microfinance has spread to five continents, and commercial microfinance programs began to emerge.

2.3.2 The Microfinance System

A typical microfinance system includes three main stakeholders: Microfinance Institutions (MFIs), loan officers, and client committees. MFIs can be NGOs, savings and loan cooperatives, credit unions, government banks, commercial banks, or nonbank financial institutions (Ledgerwood 2014). Loan officers usually serve as the liaison between the MFI and its client committees. They promote the microfinance program, identify possible client committees, stay in touch with their client committees, and ensure their client committees repay their loans on time (Siwale and Ritchie 2012). Client committees are usually self-employed, low-income entrepreneurs in both urban and rural settings. Most MFIs provide credit either through group lending or through individual-based lending. The majority of microfinance borrowers participate in the group lending program (Ledgerwood 2014). In the group lending process that Grameen Bank developed, borrowers form a group, agree to get a small group loan, and repay their loan weekly. Each individual chooses the loan size he or she will be responsible for paying each week. If any member of the group misses a payment, all members are denied future credit. This incentivizes group members to monitor other members and enforce repayment to ensure getting future loans. On the other hand, individual-based lending is similar to traditional banking and includes a direct relationship between the program's loan officer and the borrower (Hermes and Lensink 2007).

2.3.3 Microfinance Program in Fundación Paraguaya

Through its microfinance program, Fundación Paraguaya (FP) aims to promote the development of microenterprises and low-income individuals by providing financial services and regular follow-ups and workshops. Their main products include microenterprise credits, women committee credits, agricultural credits, and individual credits. In 2013, FP worked with approximately 57,000 families in Paraguay and was able to help over 6,000 families get out of poverty. Since August 2015, FP's officers also administer the Poverty Spotlight along with the microfinance program. Poverty Spotlight is one of FP's social programs that allows client committees to self-assess their level of poverty and develop a plan to overcome it (Fundación Paraguaya, n.d.-b)

For the purposes of this project, our team intends to analyze the operations of the group lending microcredit program, which specifically targets female client committees. This branch of FP accounts for 24 offices and around 86,000 client committees. Each committee in the program is composed of 15 to 20 women. FP administration intends to improve efficiency within the program as it faces a series of challenges. First, the loan officers, known as asesores, are responsible for numerous monthly tasks and feel overwhelmed. These tasks include promotion of the program to get new client committees, the establishment of new committees that require four initial meetings, monthly visits to each committee, monthly visits to poverty spotlight client committees (around 35 visits), unpredictable visits to client committees who are late in their payments, and administrative work. Each visit can take an asesor up to four hours because of the time of transport (Amarilla 2016). Second, presently the offices do not geographically limit the space where their asesores can get their client committees. This results in asesores traveling greater distances to acquire new client committees as well as visit existing ones. Third, due to the bonds of trust between client committees and asesores, many asesores are not willing to swap client committees with other offices to reduce the distance they have to travel (Sanabria 2016).

2.4 Challenges Faced by Fundación Paraguaya

In this section, we summarize the findings of research conducted by human resources trainers for FP's Poverty Spotlight program. This research, along with the information obtained in interviews, allowed us to narrow down the scope of our project to two challenges. These include the lack of planning by asesores and the zoning inefficiency of the organization.

2.4.1 Research Conducted Concerning Challenges of Fundación Paraguaya's Administration

Research conducted by FP's Poverty Spotlight training team analyzed the day-to-day activities of asesores to determine the most efficient way to increase productivity and implement the Poverty Spotlight with more commitment. It was conducted during October 2015 and sampled 10 national offices and 31 asesores, which represents 42% of all the offices in Paraguay. The research was conducted because asesores showed discontent towards their high amount of work responsibilities, which threatens to affect the quality of the job they conduct (Fundación Paraguaya, 2015).

One key finding of this research is the contrast between the expected travel time and the real travel time of the asesores, as well as the contrast in times of transport in rural areas versus urban areas. In one instance, in an urban office, a client was located 38 kilometers away from the office and according to Google Maps, it would take around 49 minutes in bus. In actuality, it took the asesor 1.3 hours for one trip. On the other hand, in a rural office, a client was located 59 kilometers away from the office and according to Google Maps, it would take around 1 hour and 13 minutes. In actuality, it took the asesor 3 hours for one trip via motorbike. From this information, it was concluded that the distance to be traveled

had great potential to be improved. The team collected the major complaints made by asesores which were travel time, lack of safety, relationship with other asesores, and work hours. The main causes identified for these complaints were lack of organization, inefficient use of time, on-the-job pressure due to numerous activities to be completed, and tardiness of the client committees for meetings. The research suggests the implementation of asesores in the Poverty Stoplight best practices and to organize the activities of the asesores including planning the meetings ahead of time (Fundación Paraguaya, 2015).

2.4.2 Individual Challenge: Lack of Planning by Asesores

One of the main challenges FP faces is the lack of organization of each asesor. The asesores report to be overloaded with work and are unhappy with the current way they are performing in their jobs. There is high pressure on the asesores because their commission depends on the amount of client committees they have. They are also required to visit Poverty Stoplight client committees even though they do not receive commission for those visits. Another challenge is the transportation cost, as asesores get reimbursed for transportation only up to a certain fixed amount of money. Moreover, asesores currently travel to visit client committees based on their availability. Therefore, sometimes they go to opposite sides of the city for visits on the same day (Sanabria 2016). Another factor is asesores usually schedule visits the day before, rather than further in advance. (Amarilla 2016). In consequence of the late planning, the asesores do not organize their schedule efficiently.

2.4.3 Organizational Challenge: Zoning Inefficiency

Zoning represents a main challenge for FP in its Microfinance Program. Omar Sanabria, the Microfinance Program manager for FP, stated during an interview that “limits were never set for the offices” (Sanabria 2016). As a result, there are client committees that are closer to an office x but are registered in office y. Consequently, within the same office, different asesores visit the same areas instead of having each asesor cover a specific area. This can lead to higher transportation costs and other tasks with non-value added time (Sanabria 2016).

The research and the information obtained from FP workers supports the need for a tool that can improve the efficiency of the asesores using industrial engineering methods such as optimization.

2.5 Optimization

Optimization intends to model a real-world problem and find the best solution to all possible alternatives and proving that the one selected is the best. Optimization seeks to maximize or minimize a mathematical function of variables, known as an objective function, subject to certain constraints, together with problem specific data. The variables, objective function, and constraints constitute a model, which is a mathematical representation of a real-world problem that aids to solve the problem computationally.

There are a variety of reasons to model real-world problems using optimization, one of them being the decision on how to best allocate limited resources. (Sarker and Newton 2007).

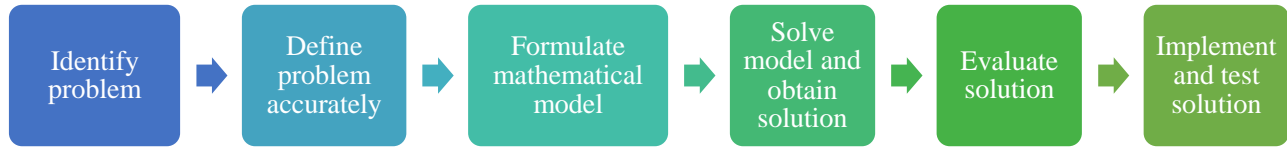


Figure 1: The Decision Making Process adapted from (Newton, 2007)

The use of optimization involves a decision-making process similar to the one shown in Figure 1. The most important and possibly difficult step is to accurately define the real problem. One must include problem assumptions, resources and parameters involved in the problem, stakeholder interests, decision variables, an objective, constraints, and the measure of effectiveness to compare alternatives. Once an optimal solution to the model is obtained, the solution remains to be interpreted and evaluated. This requires the conversion of mathematical findings into easily understood procedures, which helps decision makers introduce the changes required to reach the desired outcome. The implementation of a solution requires a frequent monitoring and re-evaluation of the performance (Sarker and Newton 2007).

Optimization has been successfully applied to a wide variety of real-world problems. In business, optimization helps companies consider complex transportation cost structures, warehouse sizes, manufacturing limitations, inventory costs, and service levels. Similar problems also exist in humanitarian organizations; therefore, they can likewise benefit from optimization-based decision making. A thesis done by Pablo Maya explores the “use of operations research models and methods to solve problems in the non-profit and humanitarian domains” (Maya 2013). He used optimization in two cases. The first one was the assignment and routing of Teacher Assistants of an Institute in Belgium that provides assistance to disabled students. The second helped the organization Landelijke Thuiszorg to plan the delivery of their home care services. The results of his research helped both organizations realize that by optimizing their operations they could increase their service level and decrease transportation costs. The savings could then potentially be used to enlarge the group of beneficiaries or invest in new programs (Maya 2013).

To address the identified challenges of FP, our team will focus on two main types of optimization problems, the Clustering problem and the Set Partitioning Problem.

2.5.1. Clustering

The clustering problem partitions a set of data points into a set of subgroups or clusters which are as similar as possible. Clustering models generally seek to form clusters that are mutually exclusive and exhaustive. As a result, data points assigned to the same cluster are more similar to each other than they are with data points in a different cluster. Clustering is commonly used in numerous applications, including data mining, collaborative filtering, customer segmentation, data summarization, dynamic trend detection, data analysis, and social network analysis (Aggarwal and Reddy 2013). Optimality of a clustering problem depends on the application it is used for such as the creation of clusters by proximity (Rao 1971). “Every clustering algorithm is based on an index of similarity or dissimilarity between data points” (Aggarwal & Reddy, 2013, p. 6). In a clustering problem, similarity measures, dissimilarity measures, or distances are used to quantify the similarity or dissimilarity of two data points. When using similarity measures, the greater the similarity coefficient, the more similar the two data points are. When using distance, a greater distance represents dissimilarity between two data points (Gan, Ma, and Wu 2007). The number of clusters in a clustering problem is typically predetermined (Gan, Ma, and Wu 2007).

An incremental approach to the clustering problem is the global k-means algorithm. The k-means algorithm consists on adding one cluster center for each cluster (Likas, Vlassis, and Verbeek 2003). The algorithm’s objective function is based on the clustering error criterion. The clustering error criterion calculates the square distance from each cluster center to each data point and then sums the distances for all points (Likas, Vlassis, and Verbeek 2003). The algorithm places cluster centers arbitrarily and proceeds to move the centers until the clustering error is at its minimum value (Likas, Vlassis, and Verbeek 2003).

Clustering is a potential solution to the organizational problem of the asesores. It can be used to group different meetings according to their geographical location and propose a schedule to asesores. We consider it in our methodology.

3. Methodology

This project intends to use Industrial Engineering methods to aid Fundación Paraguaya in improving the efficiency of its Microfinance and Poverty Stoplight programs through the completion of the objectives mentioned in Figure 2.

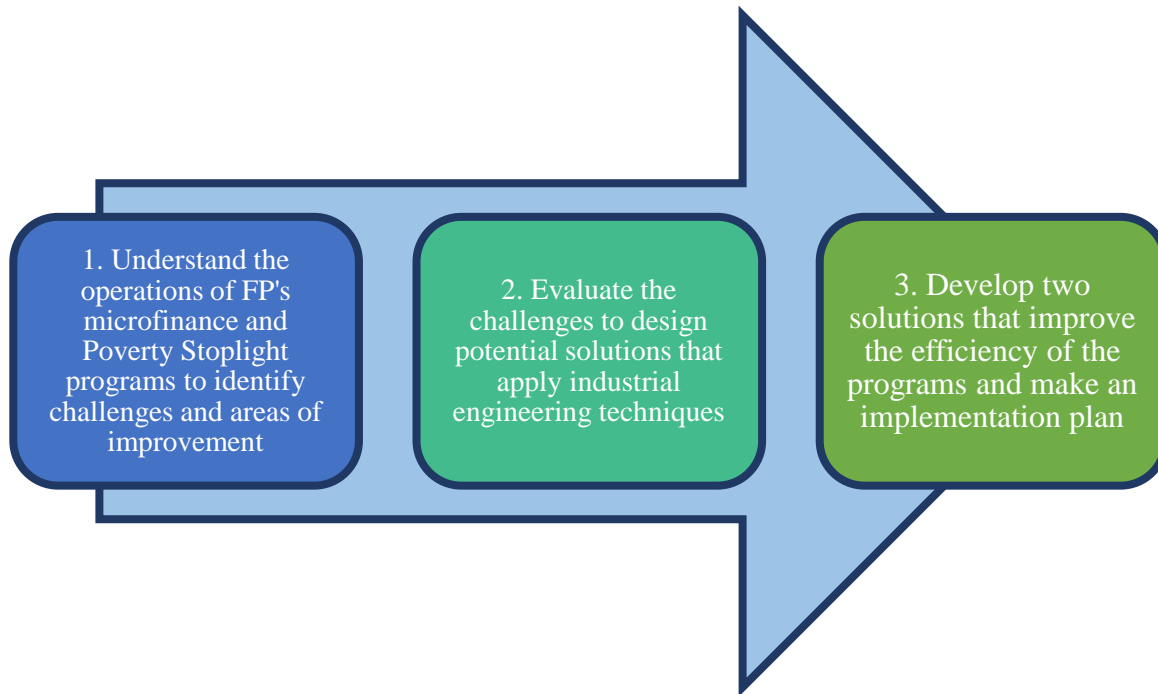


Figure 2: Project Objectives

This chapter discusses the methods carried out to achieve the determined objectives.

3.1 Understand the Operations of Fundación Paraguaya's Microfinance and Poverty Stoplight Programs and Identify Challenges and Areas of Improvement

To achieve our first objective and gain a better understanding of FP's microfinance program operations, our team traveled to Asunción, Paraguay in early January 2016. We obtained qualitative data by visiting different microfinance offices, interviewing the major stakeholders, and identifying areas for improvement with managers, asesores, and administrative staff members.

3.1.1 Visit to Fundación Paraguaya

Prior to our visit, we communicated with Martin Burt through Skype and met with him personally when he came to WPI to discuss possibilities of developing a project with FP. During one of those meetings, we determined the need to physically go to Paraguay to collect more information and understand the problem as much as possible. Martin mentioned there were challenges with the asesores of the microfinance program in terms of their efficiency. We immediately started thinking of possible

solutions using Industrial Engineering techniques. One key factor we all understood was that the problem we were addressing was not solely numerical as we had to consider human and social dimensions.

During our visit, our team went to three offices within one week. We visited the main office (HQ), an office in an urban area, and an office in a rural area. Through those visits, we were able to get a better understanding of the program's operations, understand the differences between the work environment in an urban setting and the work environment in a rural setting, and understand the challenges FP workers face every day. We documented our findings from each visit and gave a presentation to FP administration.

3.1.2 Interviews

In each of our visits, we interviewed some of the major stakeholders of the microfinance program: FP administration, the general manager, office managers, HR trainers, and asesores.

First, we met with administrative staff members to get the overall idea of the program's operations. The main objectives of this initial meeting were to meet FP's administration, to learn about the program's activities, and to establish initial goals for our stay in Paraguay and for the project. We performed conversational interviews with six administrative staff members. We documented the general processes of the program, identified challenges based on their perspective, and identified potential limitations for any change made to the program. Second, we interviewed the general manager of the microfinance program. The main objectives of this interview were to understand specific processes within the program, understand the worker incentive scheme, understand the impact of inefficiency on FP, and verify if some potential solutions could work for the organization.

Third, our team visited two offices: one in an urban setting and another in a rural setting. We met with the manager of each office to understand their role in the office, identify the challenges they face, define their day to day activities, and understand how they set goals for each office and for their workers. Fourth, we met with an HR trainer for the Poverty Stoplight program. Because asesores have to carry out Poverty Stoplight activities, this interview served to understand the details of the combination of the processes in both the microfinance program and Poverty Stoplight program, and to identify the challenges associated with combining this problem.

Finally, we met with asesores to identify all the activities they perform including meetings, calls, and administrative work. We identified the challenges they face, understood the organization of the asesores and the scheduling process of meetings, and defined the resources they use to perform their duties. All of our interviews were informal, conversational, and conducted in Spanish. These interviews shaped our goals and objectives and redefined the initial conception of the project.

3.1.3 Shadowing an Asesor

Our team shadowed one asesora in an office located in Villa Elisa, an urban district near Asunción. Through this, we observed some of the usual tasks an asesor performs, recorded the time of transportation to the meeting, and witnessed a women committee meeting.

3.2 Evaluate the Challenges and Design Potential Solutions that Apply Industrial Engineering Techniques

To achieve our second objective, our team determined challenges to address, evaluated potential project options, determined feasibility of initial solutions, and presented findings and potential solutions.

Before arriving in Asunción, our team analyzed potential project options presented by Martin Burt during a visit to WPI. Two of the ideas were determining the best route for an asesor once he knows which client committees he or she will visit that day, and allocating resources in Asunción based on Poverty Stoplight data.

While in Asunción, we were able to find out which solutions were feasible for our sponsor and their employees by gathering input through interviews. Being there for a week enabled us to think of potential solutions that could be implemented and tailored to the microfinance program's challenges. As it turned out, most of our initial thoughts would not have worked for FP because we had not considered many factors such as public transportation challenges, and the challenges of scheduling meetings. We were not aware of the combination of the Microfinance and the Poverty Stoplight Program, the relationship of trust between client committees and asesores, or the reluctance of asesores to change their working style.

By the end of our stay in Paraguay, we presented our findings to the administration. We included an analysis of the current state of the microfinance program, a list of all the work-related activities asesores do, the identified areas of improvement, and two potential deliverables that will address the identified challenges. After presenting, we were able to confirm all the information we gathered was accurate and consistent. We also obtained feedback from the FP administration.

After departing Paraguay, we thoroughly analyzed all the data we collected in our interviews, shadowing, and the reports given to us. One particular report was a research and analysis conducted on the asesores' job (Fundacion Paraguaya, 2015). This confirmed that asesores often do not plan their meetings in advance, causing them to sometimes visit the same areas in different days instead of visiting the same areas on the same days. This adds to the work-related pressure of achieving all the job

responsibilities. After reading this report, we confirmed the need for a tool to help the scheduling processes of asesores.

3.3 Develop Two Solutions that Improve the Efficiency of the Microfinance Program and the Poverty Stoplight Program and Make an Implementation Plan

After we evaluated the challenges and weighed potential solutions, our team worked to develop the tools that were going to improve the efficiency of the microfinance program. The team focused on addressing challenges found on the individual level and also on the organizational level, therefore providing two different solutions: one tool that optimizes asesores' scheduling process, and one that analyzes the impact of redistributing the microfinance program's client committees. We divided our time for these tools in two terms of seven weeks each and worked on each project separately. During our final presentation in Paraguay, the administration gave priority to improving the process of scheduling meetings. For this reason, we dedicated our first seven weeks to develop the scheduling tool, and the second seven weeks to analyze the impact of the redistribution of client committees.

Following the completion of the technical aspects of the project, our team focused on making the deliverables user friendly. After visiting Paraguay, we decided that our solutions had to be as simple as possible. To design a user-friendly platforms, we communicated regularly with managers and asesores in Paraguay via Skype to get their feedback.

3.3.1 Optimization of Scheduling Process

Through interviews conducted in January 2016 with asesores, our team identified the process of scheduling meetings as an area of improvement on the individual level of the microfinance program. As a result, our goal was to create a tool that could cluster selected meetings based on geographical location, providing the asesor a proposed daily or weekly schedule. This tool is computational and involves a spreadsheet and a Visual Basic for Applications (VBA) code. The purpose of this development was to improve the scheduling process for asesores by decreasing the time it takes for them to organize themselves. The tool proposes different groups of selected client committees that are in close proximity to suggest asesores to schedule meetings in that manner.

Before leaving Paraguay, we requested monthly asesores' schedules, which were in an Open Office spreadsheet, as well as manuals that explained the details of the microfinance program. After coming back, we analyzed the data we collected to better understand all of the tasks for which an asesor is responsible. Subsequently, we determined the activities we were going to include in the scheduling tool. We focused on activities that implied visits such as conducting the Poverty Stoplight, starting a new committee, visiting committees that have late payments, and visiting a client to renew a credit.

Through research and collaboration with our advisor Professor Andrew Trapp, we identified that a clustering model would be the appropriate option for our type of problem. Once the right model was identified, we started determining variables, setting constraints, and identifying the objective function. Following this step, the team worked on a small exemplary clustering problem with x and y coordinates. After working on a smaller problem set, the team developed a general algebraic model that can be found below. The model takes as input a data set that contains client names and coordinates and allocates them to different clusters based on proximity. In relation to our specific project, each cluster represents a day in an asesor's working schedule.

The formulation of our algebraic model is below.

Algebraic Model Formulation

Sets

| | |
|-----|---|
| C | Set of client committees, indexed by c ($c = 1, \dots C $) |
| K | Set of Clusters indexed by k ($k = 1, \dots K $) |

Parameters

| | |
|----------|---|
| ℓ^c | Fixed latitude of client c |
| n^c | Fixed longitude of client c |
| t^c | Time of meeting for client (duration) |
| e_k^c | Euclidean distance between client c and cluster k |
| b | Maximum number of meetings per cluster |
| f | Minimum number of meetings per cluster |
| u | Maximum amount of time per cluster |

Variables

| | |
|----------|---|
| ℓ_k | Latitude of centroid for cluster k |
| n_k | Longitude of centroid for cluster k |
| z_k^c | $\begin{cases} 1, & \text{If client } c \text{ is assigned to cluster } k \\ 0, & \text{otherwise} \end{cases}$ |

Model Formulation

$$\text{Minimize} \quad \sum_{c=1}^C \sum_{k=1}^K e_k^c * z_k^c \quad (1.1)$$

$$\text{Subject to} \quad \sum_{k=1}^K z_k^c = 1 \quad \forall c \in C \quad (1.2)$$

$$f \leq \sum_{c=1}^C z_k^c \leq b \quad \forall k \in K \quad (1.3)$$

$$\sum_{c=1}^C t^c * z_k^c \leq u \quad \forall k \in K \quad (1.4)$$

$$z_k^c \in \{0,1\} \quad \forall k \in K, \forall c \in C \quad (1.5)$$

$$\ell_k, n_k \text{ Unrestricted in sign} \quad \forall k \in K \quad (1.6)$$

The objective function (1.1) minimizes the total distance between client committees and clusters. e_k^c is calculated using the Euclidean distance formula $\sqrt{(\ell^c - \ell_k)^2 + (n^c - n_k)^2}$. In this formula, ℓ_k and n_k are variables. Constraint (1.2) ensures that every client gets assigned to exactly one cluster. Constraint (1.3) imposes that at least f client committees are assigned to every cluster and that the number of client committees assigned to a cluster cannot exceed b . Constraint (1.4) imposes that the total time per cluster does not exceed u .

During the implementation, we encountered one main problem. While the model (1.1)-(1.6) was mathematically correct, it was nonlinear due to two main aspects. First, the formula used to calculate the objective function contained products of variables. Second, the distance was calculated using the Euclidean distance formula that contains squares and a square root, which are not linear. Nonlinearity restricted the model from achieving a global optimal solution. Professor Trapp assisted the team by providing an alternative approach that would accomplish the same outcomes in a linear way. For more details on the modifications made to the model to make it linear see Appendix A.

The final algebraic model after the modifications is found below.

Sets

C Set of Client committees, indexed c ($c = 1, \dots |C|$)

K Set of Clusters indexed k ($k = 1, \dots |K|$)

Parameters

ℓ^c Fixed latitude of client c

n^c Fixed longitude of client c

| | |
|-------|--|
| t^c | Time of meeting for client c (duration) |
| b | Maximum number of meetings per cluster |
| f | Minimum number of meetings per cluster |
| u | Maximum amount of time per cluster |
| r | Maximum latitude value within the latitude data set |
| s | Minimum latitude value within the latitude data set |
| v | Maximum longitude value within the longitude data set |
| w | Minimum longitude value within the longitude data set |
| M^c | Large number that uses r, s, v , and w to represent furthest possible distance from any client to any cluster. (See example and explanation below) |

Variables

| | |
|--------------------------|---|
| ℓ_k | Latitude of cluster k |
| n_k | Longitude of cluster k |
| z_k^c | $\begin{cases} 1, & \text{If client } c \text{ is assigned to cluster } k \\ 0, & \text{Otherwise} \end{cases}$ |
| d_k^c | Distance between cluster k and client c if client c was assigned to cluster k |
| $\{x_k^{c+}, x_k^{c-}\}$ | Nonnegative variables that carry balance of absolute value terms from Manhattan distance |
| $\{y_k^{c+}, y_k^{c-}\}$ | Nonnegative variables that carry balance of absolute value terms from Manhattan distance |

Model Formulation

$$\text{Minimize} \quad \sum_{c=1}^C \sum_{k=1}^K d_k^c \quad (2.1)$$

$$\text{Subject to} \quad \sum_{k=1}^K z_k^c = 1 \quad \forall c \in C \quad (2.2)$$

$$f \leq \sum_{c=1}^C z_k^c \leq b \quad \forall k \in K \quad (2.3)$$

$$\sum_{c=1}^C t^c * z_k^c \leq u \quad \forall k \in K \quad (2.4)$$

$$\ell^c - \ell_k = x_k^{c+} - x_k^{c-} \quad \forall k \in K, \forall c \in C \quad (2.5)$$

$$n^c - n_k = y_k^{c+} - y_k^{c-} \quad \forall k \in K, \forall c \in C \quad (2.6)$$

$$d_k^c \geq (x_k^{c+} + x_k^{c-} + y_k^{c+} + y_k^{c-}) - M_c * (1 - z_k^c) \quad \forall k \in K, \forall c \in C \quad (2.7)$$

$$s \leq \ell_k \leq r \quad \forall k \in K \quad (2.8)$$

$$w \leq n_k \leq v \quad \forall k \in K \quad (2.9)$$

$$z_k^c \in \{0,1\} \quad \forall k \in K, \forall c \in C \quad (2.10)$$

$$x_k^{c+}, x_k^{c-}, y_k^{c+}, y_k^{c-}, d_k^c \geq 0 \quad \forall k \in K, \forall c \in C \quad (2.11)$$

$$\ell_k, n_k \text{ *Unrestricted in sign*} \quad \forall k \in K \quad (2.12)$$

The objective function (2.1) minimizes the total distance between client committees and clusters. Constraint (2.2) ensures that every client gets assigned to exactly one cluster. Constraint (2.3) ensures that at least f client committees be assigned to every cluster and that the number of client committees assigned to a cluster cannot exceed b . Constraint (2.4) imposes that the total meeting time per cluster does not exceed u . Constraints (2.5) and (2.6) ensure that the distance between clusters and client committees' latitudes and longitudes is the same as the difference of the variables x_k^{c+}, x_k^{c-} and y_k^{c+}, y_k^{c-} , respectively, and therefore maintain the Manhattan distance in a linear fashion. Constraint (2.7) imposes that d_k^c needs to be larger than the distance between clusters and client committees assigned to those clusters. Constraints (2.8) and (2.9) impose that the coordinates for each cluster center are larger than the minimum and maximum coordinates of latitudes and longitudes respectively. Constraint (2.11) ensures that $x_k^{c+}, x_k^{c-}, y_k^{c+}, y_k^{c-}, d_k^c$ are nonnegative values.

Example for M^c

Figure 3 shows the functionality of M^c . It depicts 5 client locations according to their (x, y) coordinates. The M^c parameter constrains the model to apply boundaries when searching for the latitudes and longitudes of each cluster center in the following way: $M^c = \max(|\ell^c - s|, |n^c - r|) + \max(|\ell^c - w|, |n^c - v|)$. These boundaries are reasonable because a cluster center would never be placed outside of these minimum and maximum values. In the example below, one can observe the boundaries this formula creates for the centroid location of each cluster. The lower left shaded corner is (s, w) and the upper right shaded corner is (r, v) . This allows the solver to find an optimal solution faster.

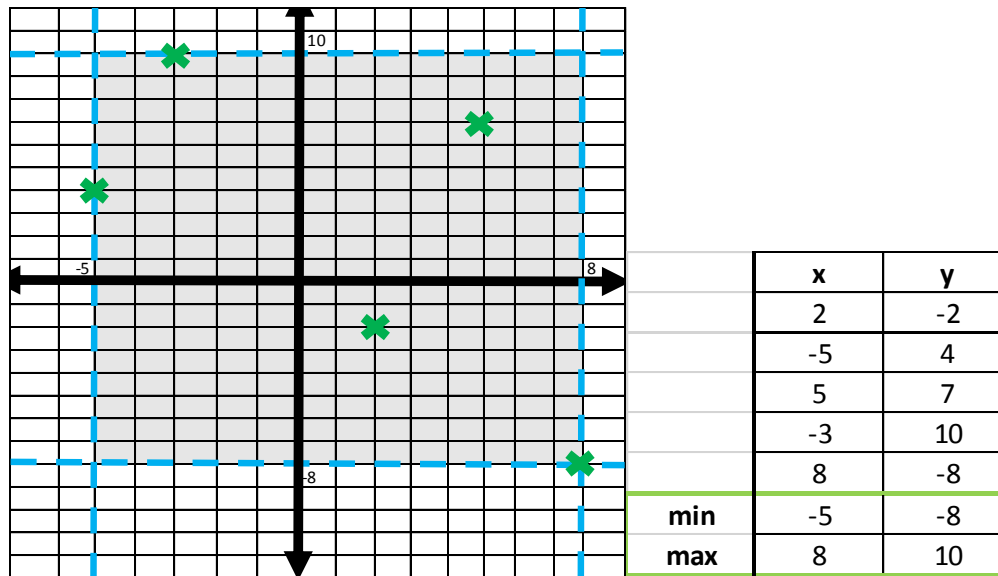


Figure 3: Visual Example of how M^c works and Coordinates Used to Create Graph.

After having an optimization model that worked effectively in a linear way, so that it could be solved with integer-programming solvers, we focused on creating an interface for the asesores, as well as on making the model dynamic using Visual Basic for Applications (VBA). This means making the model adaptable for varying number of scheduled meetings and days, and still run effectively. In addition we included some error-handling features to enhance the tool.

Testing

After the completion of the scheduling tool, our team showed it to different managers of the organization to get feedback. Once they approved the tool we requested them to ask ten asesores to track their visits for a whole week taking notes on the ID of the visited client, the name, and the duration of the meeting. After obtaining all these records we ran our tool with the same visits each asesor completed within that week to obtain an optimal schedule. Then we compared both schedules to measure the impact of the scheduling tool in terms of mileage and transportation time.

Implementation

Once the tool was finalized and the tests were completed, we met through Skype with management in FP to explain the purpose of the tool, the logic it follows and the way it should be used. One manager from FP, ran the tool so others could see the way it works and the potential it has to improve the efficiency of their work. We provided FP with an info packet, which contained instructions to run the tool, instructions to download necessary software, and a PowerPoint with detailed explanations of each tab.

3.3.2 Redistribution of the Microfinance Program's Client Committees

Through our interviews to FP's administration conducted in January 2016, our team understood the redistribution of client committees was also a challenge to be addressed. FP wanted to geographically limit each office, reducing the number of asesores that have client committees in another office's zone.

The leadership at FP determined zones in Google Maps to geographically limit the 24 offices. Figure 4 shows the representation of these newly determined zones. These divisions were determined using local knowledge of traffic, public transportation, and streets. FP's objective when determining the zones was to limit the distance asesores have to travel to meet with client committees within their zone.

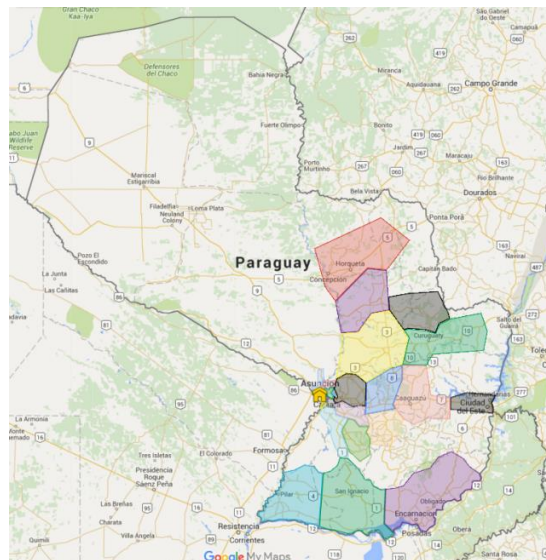


Figure 4: Zones determined by FP Officers for Each Office

Ray Casting

Our task was to provide FP with an analysis of the impact reassigning current client committees to the different zones would have on the program and its client committees. We first had to reassign the client committees to the offices that covered their area. We did this by extracting the coordinates of the arbitrarily shaped polygons FP managers created in Google Maps that represented the different offices of FP. The coordinates were in XML format, which we transferred to excel and organized as a list of latitudes and longitudes for each office. We used each list of coordinates to determine which client committees lied within each polygon. We utilized a method called Ray Casting, which determines whether a point is inside or outside a polygon. Ray Casting tests how many times a ray that initiates in a point intersects with the edges of a polygon. As seen in Figure 5 if the ray has an odd number of intersections, the point is inside of the polygon. If it has an even number of intersections, the point is outside of the polygon.

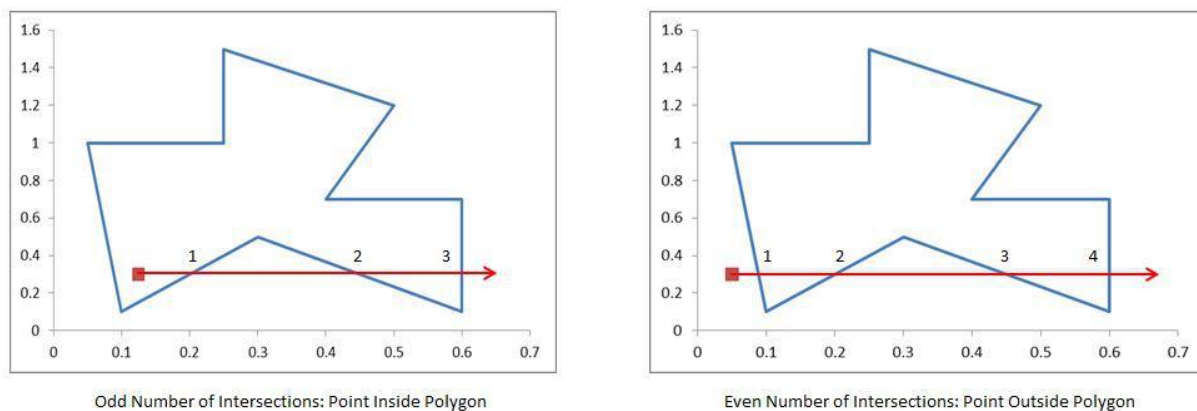


Figure 5: Ray Casting Method Functionality (Songa, 2014)

We used Bander Songa's Ray Casting Excel tool, which allowed us to input the coordinates for each polygon (office) and test all the client committees' coordinates to determine which client committees belong to each zone (Songa 2014). The tool plotted the coordinates we input for the polygons in a Cartesian plane where latitudes were x-coordinates and longitudes were y-coordinates. The test results were true if the point was inside the polygon or false if it was outside the polygon. We followed this procedure for each zone.

Once all of the client committees were assigned to a zone, we determined which ones moved offices. We assigned a 1 to the client committees who moved and a 0 to the ones who stayed in the same office. Then, we did a flow analysis by creating a From/To chart that calculated the amount of client committees that went from office x to office y. Afterwards, we calculated the total number of incoming, outgoing, and staying client committees for each office. We used this to calculate the current state and future state number of client committees in each office and calculate the difference between the current and the future scenarios. This was also used to calculate the total loan amounts of incoming, outgoing, and staying client committees for each office.

We also made a decision making tool that included a summary report for each office. The report includes information of all the client committees that are outgoing, incoming, and staying in each office. We included calculations for key metrics such as counts of how many client committees were outgoing, incoming, and staying and what that represents in loan amounts. A key feature of the tool is a sensitivity analysis that allows managers to reevaluate client committees that are more valuable than others based on a high loan amount.

Implementation

FP managers were interested in using the analysis of the impact of the redistribution of client committees and the decision making tool to reassign their client committees in a way that would decrease the total distance between offices and client committees. Furthermore, they want to repeat this analysis with their other programs including their individual loans program. For this reason, we created an info packet on how to understand the analysis and how to use it to make decisions, including how to use the sensitivity analysis in each office's report. Through a Skype meeting with FP managers, we delivered this info packet and answered questions they had about the analysis and decision making tool. We also made a step-by-step guide on how we did the analysis so they could repeat it with their other programs.

4. Results

This section discusses the components that led the team to further understand the current situation of Fundación Paraguaya. It explains how we defined the challenges we were going to address and how we came up with the solutions. Finally, it focuses on the optimization of asesores' scheduling process and the analysis of reassignment of client committees. For each of these results, the team determined the impact it has on the project.

4.1 Understand the Operations of Fundación Paraguaya's Microfinance and Poverty Stoplight Programs and Identify Challenges and Areas of Improvement

This section shows the results obtained from visiting FP, conducting interviews to key stakeholders, and shadowing asesores. These led the team to further understand the functions of FP and to identify the areas of improvement that would serve as the project focus.

4.1.1 Visit to Fundación Paraguaya

The team visited Fundación Paraguaya between January 6th and January 13th of 2016 to understand the current situation of FP and determine which challenge(s) we were going to address. We had the opportunity to be in the main office and talk to leaders of both the microfinance program and the Poverty Stoplight program as well as the founder of the organization, Martin Burt.

Through this visit, we were able to understand the organization's work environment and daily operations so we could develop a solution that would be useful and attractive for them. Figure 6 includes a general structure of the microfinance and poverty stoplight programs.

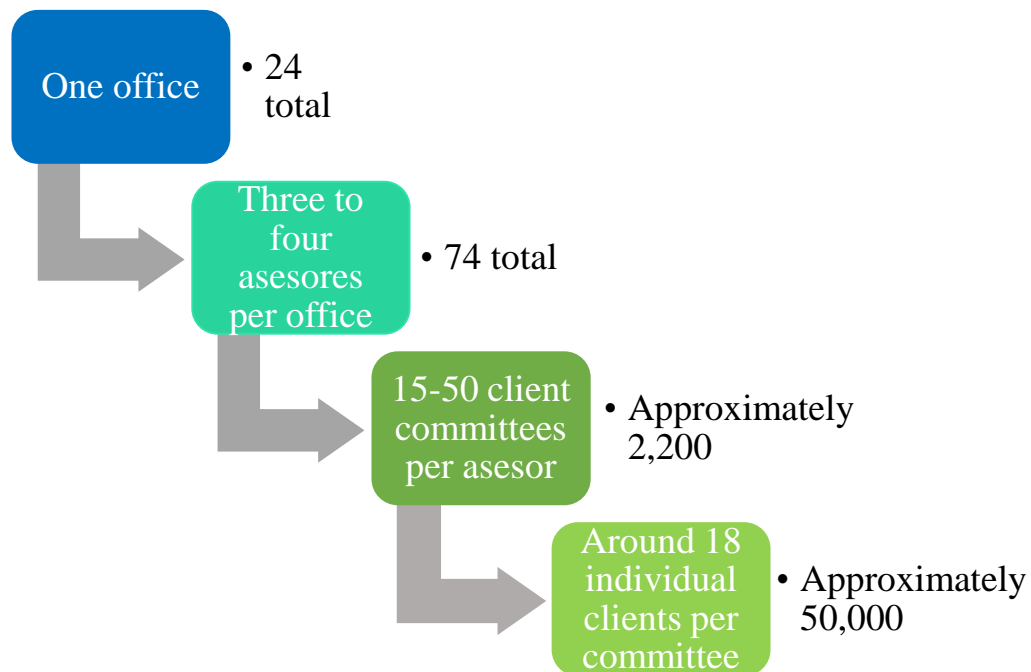


Figure 6: Hierarchical Structure of the Microfinance Program

Implications

Physically going to Paraguay allowed our team to understand the real problems the organization was facing and the scope of feasibility of a project to be developed. Learning about the structure of the organization allowed us to understand how the challenges of the asesores and client committees' distribution fit within the big picture.

4.1.2 Interviews

In our first meeting with FP's administration, the representatives gave us an overview of the microfinance program logistics. The program has two major components: individual loans and group loans. Our team was assigned to work with the group loans program. During this meeting, some representatives expressed the challenge of not having specific zones for each office. In its current state, asesores from different offices go to the same areas to look for new client committees and to visit their own. For this reason, the administration intends to create an optimal zoning plan to limit each office. Determining zones for each office implies that many asesores will be impacted and will have to change their client committees based on the modifications these new zones suggest. The main limitation mentioned by the administration towards changing client committees, was the bonds of trust between client committees and asesores. Most asesores would not trade their client committees with other asesores even if this change will increase their efficiency. Another challenge was the lack of an organized process to schedule client committees' meetings.

During this meeting we also learned about all the different activities asesores are responsible for. Figure 7 presents a summary of all the meetings and activities an asesor does monthly. All the types of meetings are value added activities as they add value to the client committees. Activities that fall in the administrative work criteria and other activities criteria are non-value added activities. This means that process improvements can help decrease the time invested in those non-value added activities.

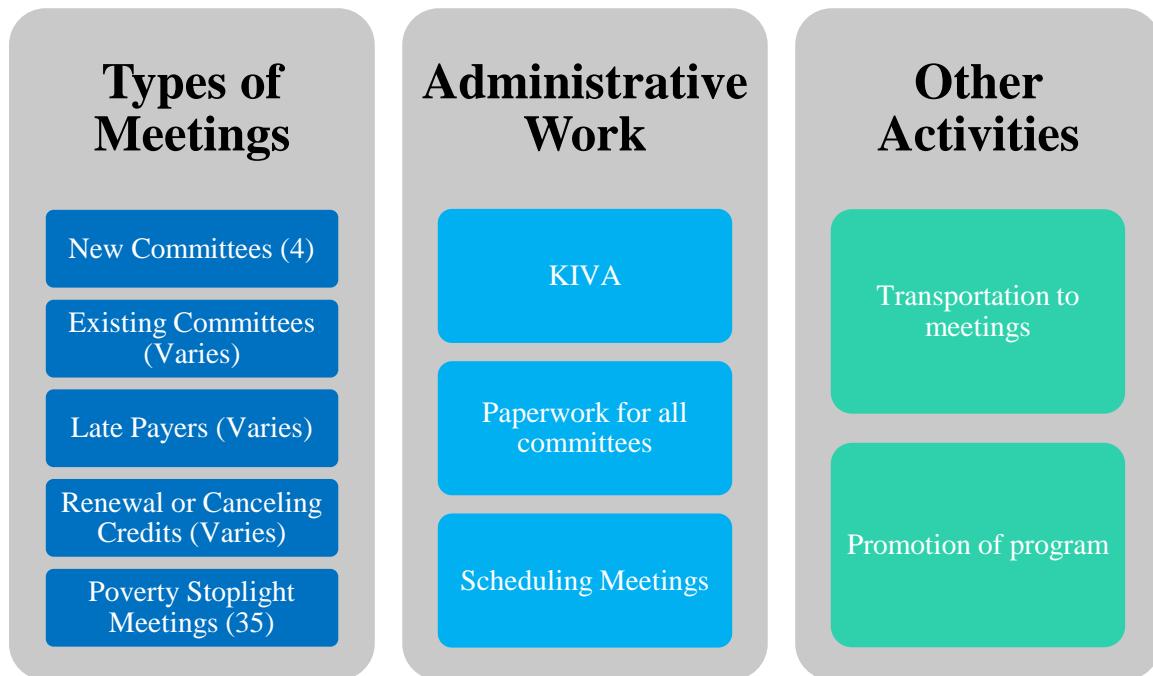


Figure 7: Summary of Asesores Meetings and Activities

Our second meeting was with the general manager of the microfinance program. He explained the reason asesores travel further distances to get to client committees. In FP's microfinance program each office and asesor has production goals set for them in terms of number of client committees they need to reach. If an asesor is not able to get enough client committees to meet the goal, they have to travel further distances to get client committees. Each committee is usually composed of 17 or 18 women who get a group credit in which each pays an individual fee of their choosing. They get a credit for four months and then it is either cancelled or renewed. He mentioned that the impact of the program's inefficiencies was the time wasted while traveling long distances to visit client committees on a daily basis. This time could be reduced if asesores scheduled meetings that were closer together on the same day and if offices had a geographical limit. In addition, we discussed with the manager the possibility of implementing a tool to help asesores create efficient routes for each day. He mentioned asesores won't have more than four meetings in a day and asesores are capable of determining their own routes. Another solution we

discussed was the reassigning of all client committees based on their location and he emphasized the difficulty of executing these changes. Nevertheless, the manager mentioned that if FP's administration was interested in moving forward with the redistribution of client committees it would be implemented.

The third group of meetings we had was with the managers of the individual offices who explained several aspects of the program. First, when the program started, FP only had a few offices. As FP started to expand, they never transferred client committees to the appropriate office, nor set geographical limits to each office. Therefore, asesores ended up having client committees not only in their zone but in all its surroundings. Second, as we heard in the previous interview, asesores travel further distances to meet their goals. In addition, client committees are mostly acquired through referrals of other client committees and these may be in other zones. Third, one of the managers showed us an example of the amount of monthly meetings an actual asesora has per month. These are shown in

Table 1. He also mentioned the responsibilities each asesor has may vary depending on the amount of time they have worked as an asesor. For example, new asesores will spend more time advertising the program to get client committees than tenure asesores. Fourth, the manager mentioned that each asesor makes his or her own schedule, most of the times based on client availability.

The following table represents the monthly meetings of an asesora named Mariana. This asesora was in charge of 69 committees, which is around 1,104 individual clients. The total meetings per month were 78 which averages to 3.9 meetings per day if using a 20 working day month. When we were in Paraguay, we realized that having 3.9 meetings per day is highly unlikely and probably impossible due to long distances they have to travel, especially when the meetings are far apart from each other. This results in asesores working overtime as well as weekends.

Table 1: Example of an Asesor's Monthly Meetings

| Types of Meetings | Number of Meetings (Monthly) |
|--|-------------------------------------|
| Renewal | 13 |
| Poverty Stoplight | 35 |
| Late Payers | 12 |
| New Committees | 8 |
| Follow-up | 10 |
| Total Meetings per Month | 78 |
| Average Meetings per Day (based on 20 working days) | 3.9 |

During our fourth meeting, we met with the HR trainer for the Poverty Stoplight program. The main takeaways from this interview were learning that every office runs differently depending on each manager, and that the three priorities of the programs were to give emphasis to new committees, give more follow-ups to bad committees, and get client committees for the Poverty Stoplight program.

In our final interview, we met with asesores from different offices. In summary, from these interviews we learned asesores make their own schedules and attempt to balance the different activities and meetings. To move around, some use public transportation, others use private cars, and others use motorcycles. Their main challenge is the amount of responsibilities they have and the lack of time to complete these activities. The asesores we interviewed were open to change their way of completing their tasks if it implied an increase in efficiency.

Implications:

Interviewing Martin Burt, managers, and asesores enabled us to define the scope of the project with the input of all parties involved. We were able to understand the need for improvement in the organization of the asesores and the consequences of the lack of zoning of the client committees.

There were four main takeaways from these interviews. First, asesores have numerous activities and responsibilities and therefore are working excessive hours. Second, asesores travel long distances to meet their clients that are scattered all around the region. Third, asesores have meetings that are very far apart from each other on the same day. Finally, asesores are open to change their organization methods for the improvement of their work.

4.1.3 Shadowing an Asesor

Another opportunity in Paraguay was shadowing an asesora for half of a day in the Villa Elisa office. We arrived early in the morning to the office and interviewed Amalia to learn about the different activities she conducts every day. We gained a better understanding of the amount of administrative work that asesores need to do apart from the client committee visits. On this particular day, Amalia was going to conduct two visits: one in the morning and one in the afternoon. The morning one was in Villeta, which according to Google Maps is 45 minutes away. This estimate is accurate when using personal transportation, which is not common for asesores in urban offices. In Figure 8, we broke down all of the activities of this visit and their corresponding completion times.

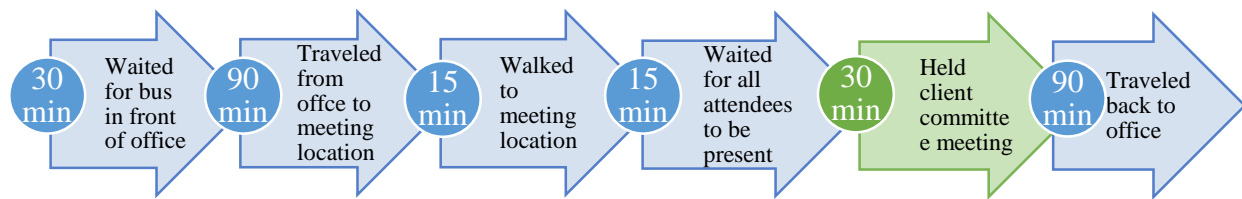


Figure 8: Breakdown of Activities during Committee Visit

We traveled to Villeta using public transportation (bus), which took around 30 minutes to arrive to the station where we were waiting, and one and a half hours to get to Villeta. After our arrival, we walked on a dirt road for around 15 minutes until we arrived to the house of the client committee president. After we got there, we waited around 15 more minutes until all the members of the group (except for one) arrived. The purpose of that meeting was to put pressure on the group because they were late on their payment. The meeting lasted for around 30 minutes, after which we took the bus back to the Villa Elisa office. We waited again around 15 minutes for the bus and the ride back took around 1 hour and a half again. After this experience, we were able to understand that even though the meeting only lasted 30 minutes, more than 3 hours were used on transportation. The blue arrows in Figure 8 represent waiting and transportation which are non-value added activities. The only value-added activity is shown in the green arrow which was the actual meeting.

Implications

After shadowing an asesora, we understood the challenge of commuting to and from meetings. We also confirmed that scheduling meetings that are far apart from each other on the same day worsens the situation. We understood that distances are not directly related with the time of travel stated in Google Maps due to irregularities in the roads, traffic, and the differences in modes of transportation.

This experience confirmed the need to group nearby meetings in the same day to avoid traveling long distances for a single meeting. In addition, we gained first-hand experience concerning the connection asesores have with their client committees, which is based on trust and respect, and how it raises a challenge when considering reassigning clients.

4.2. Evaluate Existing Challenges and Determine Solutions

Our team determined the challenges we were going to address, evaluated potential project options, and determined the feasibility of initial solutions, and presented findings and potential solutions.

Before arriving to Paraguay we had two project ideas: determining the best route for an asesor once the client committees to visit are known for that day, and allocating resources in Asunción based on

Poverty Spotlight data. Both ideas deemed as not feasible for different reasons. First, because asesores rarely meet more than four client committees in a day, determining the best route for such a small number of meetings would not add much value. Second, the Poverty Spotlight program consists of empowering people to improve their own quality of life, rather than distributing resources.

During our first meetings with FP managers we were notified the lack of zoning of client committees was an issue FP was interested in addressing, but after interviewing some managers and asesores, we understood it was important but not the only thing we could do. Based on the people we interviewed, we determined which of the major challenges could be addressed with Industrial Engineering techniques. We narrowed the challenges down to an individual challenge and an organizational challenge, therefore making an impact on both the day-to-day activities of the asesores, as well as the overall path of the organization. The individual challenge was the lack of organization of the asesores in terms of scheduling meetings, and the lack of an electronic agenda. To address this challenge, we decided to develop a scheduling tool that groups selected meetings into groups based on proximity and allows asesores to create a more optimal schedule. The organizational challenge was the lack of zoning and the problem of having asesores from one office visit other offices' areas to meet with their client committees. To address this challenge, we simulated the assignment of client committees to offices based on their geographical location using Bander Songa's ray casting tool, we analyzed the impact of these changes, and we provided FP with a decision-making tool. Figure 9 explains the path our project will take.

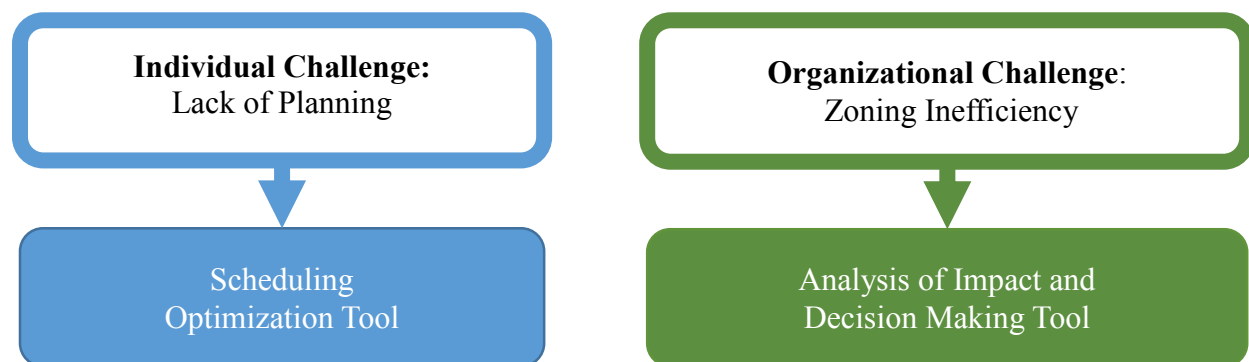


Figure 9: Challenges Addressed during our Project

After determining the approach we wanted to follow, our final meeting in Paraguay was a presentation to FP management. We obtained their feedback, and received their approval to proceed with these two projects. Once we arrived to WPI, we determined with the help of our advisor Professor Trapp, that a proximity based clustering approach was going to be the starting point of our scheduling tool. This

way, meetings could be grouped based on proximity with the objective of minimizing the distance traveled.

Implications

Evaluating the challenges led us to focus our project in the organization of the asesores and the redistribution of clients. This analysis led us to focus on what FP management indicated was a challenge, further underscoring what we personally observed the asesores needed to become more efficient and, as a consequence, find more balance in their lives and activities.

4.3 Solutions that improve the efficiency of the Microfinance and the Poverty Stoplight programs and Implementation Plans

This section discusses the two solutions we developed: the optimization of the scheduling process and the redistribution of client committees.

4.3.1 Optimization of Scheduling Process

This section includes the model logic, the Excel scheduling tool description, the application of VBA, and the impact of the tool.

Model Logic

Our Scheduling Tool model seeks to minimize the total distance traveled by asesores by assigning meetings that are closest to each other on the same days. Some of the constraints include that days have a minimum and maximum number of meetings, each meeting gets assigned to exactly one day, and the total meeting time per day cannot exceed a time determined by the asesor. The algebraic model used to build this optimization based tool can be found in Section 3.2.1. As a result of this tool, a new scheduling process was created, as depicted in Figure 10.

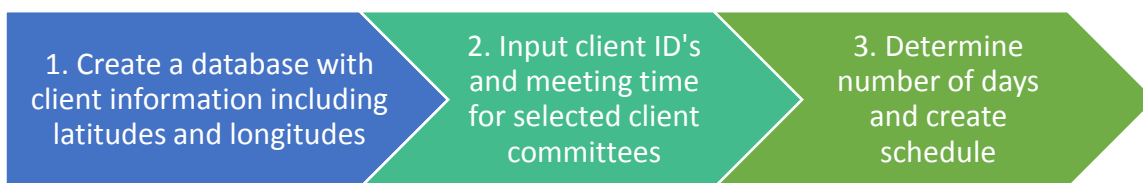


Figure 10: New Scheduling Process

Scheduling Tool Description

The objective of this tool was to reduce the amount of times an asesor has to travel to the same zones on different days of the week as well as, indirectly, reduce the amount of time an asesor spends on traveling to get to each meeting.

We developed an optimization tool using Microsoft Excel, OpenSolver, and Visual Basic for Applications (VBA) that employed the clustering algorithm explained in our methodology (Section 3.3.1). We designed the tool in Spanish using recommendations gathered during our visit and aimed to make it as user friendly as possible. The tool is intended to be used by asesores who wish to schedule meetings with a number of client committees for a specific number of days. The tool provides asesores a suggested schedule of the days they wish to schedule for and shows which client committees should be scheduled together.

The tool includes four main tabs. Figure 11 shows the *Selected Clients* tab where the asesor picks which client committees he or she would like to meet for the specified number of days. The tab includes buttons to help the asesor perform different operations. These include a button to re-start (which clears all the data in the tab), a button to manually enter client committees' IDs and duration of meetings, a button to show the names of the client IDs entered, and a button to create the schedule. In this tab the asesor will input or copy and paste the ID number for the selected client committees into the first column and then click the button "Check Names" to verify that the IDs entered correspond to the correct client committees. The asesor also has the option of clicking the "Add Client" button to manually enter the client IDs and the duration of the meetings one by one. Once all the information has been input (that is, the client IDs and the duration of all the meetings), the asesor is ready to create the schedule by clicking the "Create Schedule" button and specifying the number of days to schedule.

| Client ID | Client Name | Latitude | Longitude |
|-----------|--------------------------------|------------|------------|
| 1742857 | Damasia Avalos | -25.306954 | -57.418549 |
| 3547775 | Josefina Rios | -25.268936 | -57.491822 |
| 5108410 | Noemi Quiñones | -25.294604 | -57.521281 |
| 820386 | Jacinta Ojeda | -25.294604 | -57.521281 |
| 905046 | Lucia Rodriguez | -25.217808 | -57.442108 |
| 3880475 | Cristina Rodriguez | -25.304886 | -57.43138 |
| 2008632 | Graciela Torres | -25.314244 | -57.389324 |
| 1478965 | Patricia Palma | -25.293973 | -57.417941 |
| 4428045 | Julia Cabrera | -25.210921 | -57.448296 |
| 889165 | Teresa Martinez | -25.274551 | -57.506792 |
| 1059030 | Andresa Brites | -25.287521 | -57.521024 |
| 1579341 | Isabel Sanchez | -25.303753 | -57.415289 |
| 2662300 | Mariana Saldivar | -24.813466 | -56.52333 |
| 3000733 | Sonia Gimenez | -24.684067 | -56.390261 |
| 2959883 | Inocencia Insaurralde | -24.191004 | -56.605805 |
| 3677880 | Pelagia Martinez | -24.300913 | -56.423556 |
| 5237440 | Liza Franco | -24.474235 | -56.118732 |
| 2112120 | Cresencia Esquivel | -24.683043 | -56.392931 |
| 2426425 | Daniela Franco | -24.973512 | -56.307206 |
| 6854064 | Nilsa Mancuello | -24.65923 | -56.438016 |
| 5707903 | Aline Duarte | -24.81529 | -56.72881 |
| 1315215 | Maria Estigarribia | -24.816322 | -56.733656 |
| 3473561 | Marta Silva Alviso | -57.14265 | -25.332612 |
| 4881686 | Nancy Elizabeth Morales Meza | -57.131196 | -25.376552 |
| 826051 | Rumilda Montiel | -57.190521 | -25.374004 |
| 4079882 | Alba Mercedes Morales Amarilla | -57.071449 | -25.253105 |
| 2681664 | Lidia Aquino Vargas | -57.062654 | -25.284268 |
| 3416869 | Yohana Iris Paz Ortiz | -57.086994 | -25.265919 |

Figure 12: Database Tab

Figure 13 shows the *Settings* tab where asesores or managers will be able to change the minimum number of meetings, the maximum number of meetings per day, and the maximum meeting time that should be allowed by the model. This tab also includes other parameters that are needed for the VBA code such as a count for number of client committees and number of days.

| | | |
|------------------------------------|-----|------|
| Minimum Meetings per Day | 3 | Edit |
| Maximum Meetings per Day | 9 | Edit |
| Maximum Meeting Time per Day (min) | 360 | Edit |

| | |
|---|----|
| Number of Days | 5 |
| Number of Clients in Database | 22 |
| Number of Clients Selected | 15 |
| Number of Meetings Selected with Specified Time | 15 |
| Quantity of Duplicate Clients | 1 |

Figure 13: Settings Tab

The fourth tab is the *Proposed Schedule* tab, which is essentially the output of the model. This tab is created each time the model runs, which occurs when the asesor clicks on the Create Schedule button. It displays the different clusters of client committees created by the optimization model. The names of the client committees are shown below a heading “Day x” as shown in Figure 14. The use of optimization ensures that all the client committees in a group are closer to the client committees in the same group than to the client committees in other groups.

| Day 1 | Day 2 | Day 3 | Day 4 | Day 5 |
|----------------|-----------------|-----------------|------------------|--------------------|
| Noemí Quiñonez | Josefina Rios | Damasia Avalos | Mariana Saldivar | Lucía Rodriguez |
| Jacinta Ojeda | Patricia Palma | Graciela Torres | Sonia Gimenez | Cristina Rodriguez |
| Andresa Britez | Teresa Martinez | Isabel Sanchez | Nilsa Mancuello | Julia Cabrera |

Figure 14: Proposed Schedule

Using VBA

To develop this tool, we used OpenSolver and VBA. OpenSolver is a free Excel add-in that enables the formulation and solution of mixed-integer optimization problems in Excel. It uses CBC, a free open-source solver, to optimize problems (Mason 2012) . This allows the tool to create a schedule for the asesores to follow, based on number of client committees selected and number of days determined which might change every time. Through VBA we were able to provide this flexibility to our tool by creating variables in the code named *NumClient* (number of client committees) and *NumClusters* (number of

days). These variables referred to cells in the *Settings* tab that counted the number of client committees selected and the number of days determined respectively. Our entire code can be found in Appendix B.

VBA also allowed us to improve our tool with error-handling capabilities. We inserted message boxes for the following errors that might occur when using the model, as shown in Table 2.

Table 2: Possible Errors and their Message Boxes

| Error | Error Message |
|--|---|
| Duplicates in clients selected | “Delete one of the client committees highlighted in red” |
| Duration of a meeting is not specified | “All selected client committees need a specified duration of meeting” |
| Selected client committee is not in database tab | “Check IDs of selected client committees or add client to database tab” |
| Selected client committees divided by number of days is smaller than minimum meetings per day | “Reduce the number of allowed meetings per day or schedule for less days” |
| Selected client committees divided by number of days is larger than maximum meetings per day | “Increase the number of allowed meetings per day or schedule for less days” |

Impact

In order to determine the potential impact of our tool in the organization, we collected a weekly schedule for ten asesores, and compared these ten schedules with ten schedules that the tool suggests, based on mileage and transportation time. Both groups of schedules were created based on the same meetings and number of days for each case. We created maps for both schedules for the ten different cases and indicated each day with different colors. From these maps we were able to calculate the distance and time traveled each day by creating driving routes from the main office to the meetings, coming back to the office at the end of the day.

Figure 15 shows the schedule created by an asesora in Luque (a) and the same schedule created with our tool (b). In these figures, the clustering concept is evident as the meetings that are closest are grouped together. Map (a), shows meetings on the same day scattered around the area as indicated by the yellow, blue, and purple dots. Comparatively, map (b) shows the tool-scheduled meetings that are closest to each other are grouped together as shown with the colored dots. In this specific case, the total reduction in distance by using the tool was 50.9% and the reduction in time traveled was 46.47%.

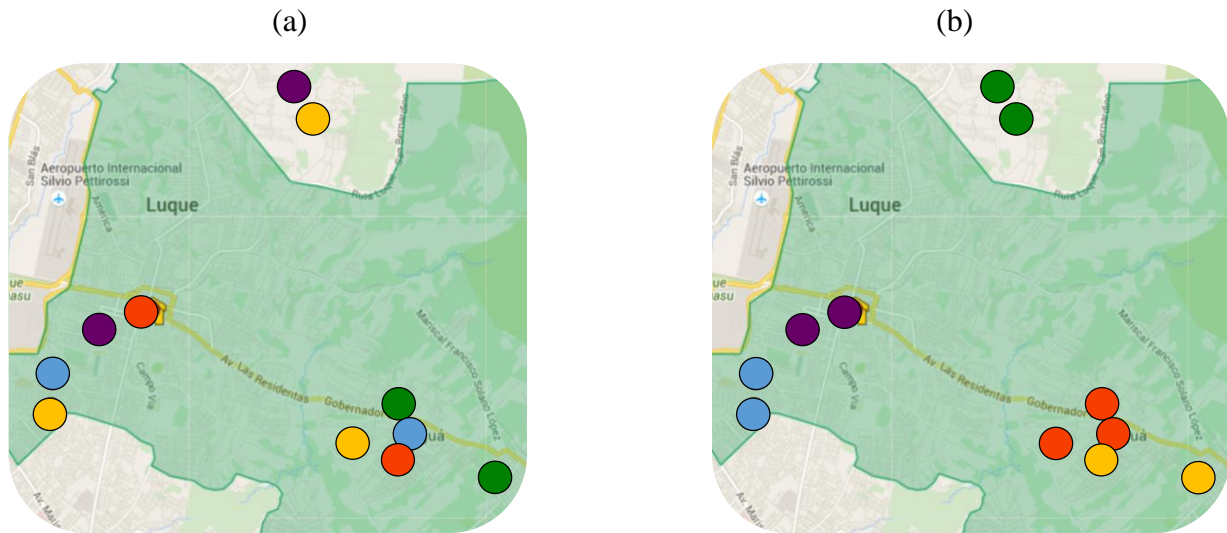


Figure 15: Schedule of an Asesor in Luque and Schedule of Luque's Asesor Made with the Tool

In addition to the maps, we created a summary of the impact of the schedule created with the tool for all ten records which can be found in Table 3. The ten schedules we received from FP can be found in Appendix C.

Table 3: Comparison between Asesores' Schedule and our Tool's Schedule

| Office Name | Number of Days | Number of Visits | Miles Traveled with Asesor's Sechedule (mi) | Miles Traveled with Tool's Schedule (mi) | Percentage Difference | Travel Time with Asesor's Schedule (min) | Travel Time with Tool's Schedule (min) | Percentage Difference |
|-----------------|----------------|------------------|---|--|-----------------------|--|--|-----------------------|
| Luque | 5 | 11 | 108.83 | 53.77 | -50.59% | 340 | 182 | -46.47% |
| Paraguarí | 2 | 4 | 78.81 | 55.55 | -29.51% | 180 | 136 | -24.44% |
| Ybycuí | 3 | 5 | 122.86 | 89.29 | -27.32% | 227 | 167 | -26.43% |
| San Lorenzo | 5 | 10 | 112.96 | 83.38 | -26.19% | 355 | 278 | -21.69% |
| Asunción | 4 | 9 | 53.318 | 41.926 | -21.37% | 242 | 178 | -26.45% |
| Coronel Oviedo | 2 | 5 | 10.32 | 8.63 | -16.38% | 48 | 40 | -16.67% |
| Encarnación | 3 | 5 | 118.36 | 103.33 | -12.70% | 249 | 219 | -12.05% |
| Santaní | 5 | 10 | 294.786 | 280.66 | -4.79% | 446 | 431 | -3.36% |
| Concepción | 1 | 3 | 7.04 | 7.04 | 0.00% | 37 | 37 | 0.00% |
| Ciudad del Este | 3 | 4 | 14.17 | 14.25 | +0.56% | 55 | 55 | 0.00% |
| Total | 33 | 66 | 921.454 | 737.826 | 19.93% | 2179 | 1723 | 20.93% |

As showed in Table 3, the total reduction in distance by using the tool was 19.93% and in terms of reduction of time it was 10.93%. In addition, there are some offices such as the Luque office where the mileage reduction was 50.5%, significantly higher than other offices. On the other hand, the office of Concepción did not present any changes in the schedule because the schedule was completed for only a single day. Also, the office of Ciudad del Este actually showed an *increase* of 0.08 miles when the schedule is completed with the tool but the time of travel remains the same. This minor, negative anomaly is simply because the grouping suggested by the tool requires the asesor to go through a less direct path to reach its destination.

For this analysis we included the ten records of schedules FP provided us. This analysis omits duplicates found in each record, as well as client committees who did not have geographical references.

Implications

Through our limited experimentation, this tool has the potential to impact the work of 74 asesores on a weekly basis by reducing approximately 21% of the time they spend traveling and allowing them to use that time to either meet with more committees, complete other tasks, or find balance in their lives. The tool also has the potential to decrease the mileage traveled by approximately 20%, which will end up decreasing the amount of Guaraníes (Paraguayan currency) spent in transportation by the organization and the asesores.

4.3.2 Redistribution of FP's Microfinance Program's Committees

In this section we discuss the analysis of reassigning committees to their respective geographical zone (determined by FP) in terms of the client committees and the loans that moved to another office, and a summary of the analysis. We also discuss the results of the decision making tool we created to aid FP managers in making decisions and an implementation plan for this deliverable.

Analysis of Reassignment

After we reassigned committees to their appropriate zone, we organized the information in a table as shown in the Figure 16. We divided the table into three sections which are color-coded each as follows: client information in dark blue, current office information in light blue, and future office information in green. The client information included the client IDs, client name, their respective loan size, and their latitudes and longitudes. The current office information included the current office number, the current office name, the latitudes and longitudes of the current office, and the distance to the current office. The future office information includes the future office number, the future office name, a calculation of whether or not the committee changed from one office to another, the latitudes and longitudes of the future office, and the distance to the future office. This table was a result of the ray casting analysis done

for all committees for each of the 24 zones. It was used to determine and count which committees changed and which committees stayed in the same office.

| Client Information | | | | | | Current Office Information | | | | | Future Office Information | | | | | |
|--------------------|---------|---|-----------|----------|-----------|----------------------------|----------------|---------------------------|----------------------------|----------------------------|---------------------------|---------------|---------|--------------------------|---------------------------|---------------------------|
| Client ID | FP Id | Name | Loan Size | Latitude | Longitude | Current Office Number | Current Office | Latitude (Current Office) | Longitude (Current Office) | Distance to Current Office | Future Office Number | Future Office | Changes | Latitude (Future Office) | Longitude (Future Office) | Distance to Future Office |
| 4799276 | 7644007 | RNOFFER AVALOS, DAMIANA MARLENE MONSERR | 28524171 | -25.358 | -57.599 | 2 | Auacion | -25.30344 | -57.6127 | 6.221082645 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 1.97970089 |
| 4863197 | 7705562 | GASPARINI VIERA, KATHERINE MABIL | 68309768 | -25.353 | -57.628 | 20 | Lamhure | -25.34022 | -57.59798 | 3.334682644 | 20 | Lamhure | 0 | -25.34022 | -57.59798 | 3.334682644 |
| 2208651 | 7469120 | VIERA MEDINA, YENY ESMILCE | 67963020 | -25.344 | -57.6 | 20 | Lamhure | -25.34022 | -57.59798 | 0.466770534 | 20 | Lamhure | 0 | -25.34022 | -57.59798 | 0.466770534 |
| 829991 | 7620447 | ARCE PINTOS, MARCELLINA | 35176016 | -25.335 | -57.603 | 2 | Auacion | -25.30344 | -57.6127 | 3.642232318 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 0.7090441 |
| 4798853 | 7755583 | MALDONADO DOMINGUEZ, KATIA JAZMIN | 18047497 | -25.340 | -57.607 | 2 | Auacion | -25.30344 | -57.6127 | 5.0983308 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 1.33220884 |
| 2475977 | 7571959 | LEZCANO DE AREVALO, MARGARITA GENARA | 79520391 | -25.339 | -57.572 | 2 | Auacion | -25.30344 | -57.6127 | 5.689439954 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 2.614421405 |
| 4831575 | 7589488 | MEDINA DE MIRELES, LOURDES MARINA | 26408803 | -25.353 | -57.64 | 2 | Auacion | -25.30344 | -57.6127 | 6.156100967 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 4.453329029 |
| 4196254 | 7775228 | DIAZ FALCON, NILDA ELIZABETH | 18552719 | -25.324 | -57.573 | 20 | Lamhure | -25.34022 | -57.59798 | 3.091247533 | 20 | Lamhure | 0 | -25.34022 | -57.59798 | 3.091247533 |
| 1010860 | 7420859 | LOPEZ VDA DE GONZALEZ, TEODORA RAFAELA | 39729041 | -25.345 | -57.583 | 7 | Villa Elisa | -25.35237 | -57.57195 | 1.380967526 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 1.596475927 |
| 2363827 | 7605153 | NUÑEZ GIMENEZ, MODESTA ELIZABETH | 25899029 | -25.361 | -57.606 | 2 | Auacion | -25.30344 | -57.6127 | 6.435704155 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 2.447141722 |
| 3177185 | 7765784 | REY TORRES, LISLE MONSERRAT | 19645311 | -25.33 | -57.578 | 20 | Lamhure | -25.34022 | -57.59798 | 2.307266089 | 20 | Lamhure | 0 | -25.34022 | -57.59798 | 2.307266089 |
| 3282630 | 7595150 | ROA CARDOSO, MARIA EMILCE | 64702153 | -25.36 | -57.605 | 2 | Auacion | -25.30344 | -57.6127 | 6.356618098 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 2.309792335 |
| 3917259 | 7769496 | CARMONA, NILDA ROSSANA | 13683113 | -25.349 | -57.603 | 2 | Auacion | -25.30344 | -57.6127 | 5.158996689 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 1.099252526 |
| 1940337 | 7457972 | CARDOZO DE ZENA, MARIA LUISA | 6654798 | -25.343 | -57.61 | 20 | Lamhure | -25.34022 | -57.59798 | 1.246874141 | 20 | Lamhure | 0 | -25.34022 | -57.59798 | 1.246874141 |
| 2109259 | 7592615 | AYALA VALDEZ, IDALINA | 84339783 | -25.354 | -57.639 | 2 | Auacion | -25.30344 | -57.6127 | 6.212412768 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 4.397686874 |
| 2177234 | 7747911 | ROJAS GONZALEZ, MARIA CONCEPCION | 13866299 | -25.349 | -57.594 | 20 | Lamhure | -25.34022 | -57.59798 | 1.055041561 | 20 | Lamhure | 0 | -25.34022 | -57.59798 | 1.055041561 |
| 3404363 | 7781187 | DIAZ VDA DE SEGOVIA, VERONICA LUCIA | 23747862 | -25.337 | -57.603 | 20 | Lamhure | -25.34022 | -57.59798 | 0.618639669 | 20 | Lamhure | 0 | -25.34022 | -57.59798 | 0.618639669 |
| 1616244 | 7647631 | GONZALEZ DENIS, ROSA BLANCA | 75888892 | -25.355 | -57.608 | 20 | Lamhure | -25.34022 | -57.59798 | 1.927389127 | 20 | Lamhure | 0 | -25.34022 | -57.59798 | 1.927389127 |
| 3417397 | 7783980 | AYALA AGUDO, CYNTHIA NATALIA | 13676440 | -25.356 | -57.614 | 20 | Lamhure | -25.34022 | -57.59798 | 2.381261381 | 20 | Lamhure | 0 | -25.34022 | -57.59798 | 2.381261381 |
| 851450 | 7736560 | VILLALBA DE DELVALLE, FELIPA MABEL | 28973997 | -25.349 | -57.594 | 20 | Lamhure | -25.34022 | -57.59798 | 1.055041561 | 20 | Lamhure | 0 | -25.34022 | -57.59798 | 1.055041561 |
| 2286717 | 7482550 | VAZQUEZ DE MACIEL, SANDRA ELIZABETH | 26858282 | -25.332 | -57.592 | 20 | Lamhure | -25.34022 | -57.59798 | 1.093902006 | 20 | Lamhure | 0 | -25.34022 | -57.59798 | 1.093902006 |
| 793390 | 7555376 | BORDON, MARIA INES | 40347771 | -25.310 | -57.608 | 2 | Auacion | -25.30344 | -57.6127 | 1.793586097 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 2.564477965 |
| 3642433 | 7590498 | ZORRILLA VILLANUEVA, LIZ MARGARITA | 35487305 | -25.369 | -57.607 | 2 | Auacion | -25.30344 | -57.6127 | 7.312411984 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 3.320606082 |
| 4184855 | 7642491 | SANTANDER ROBLES, LIZ MARIA | 37699183 | -25.349 | -57.607 | 2 | Auacion | -25.30344 | -57.6127 | 5.0983308 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 1.332208884 |
| 636540 | 7546009 | CANO PARODI, VERNANCIA CONCEPCION | 43040110 | -25.318 | -57.61 | 2 | Auacion | -25.30344 | -57.6127 | 1.641588416 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 2.750282177 |
| 3602563 | 7757014 | AGUIERO AVALOS, MONICA MONSERRAT | 16396947 | -25.347 | -57.621 | 20 | Lamhure | -25.34022 | -57.59798 | 2.433099106 | 20 | Lamhure | 0 | -25.34022 | -57.59798 | 2.433099106 |
| 1833377 | 7453811 | VARGAS, JULIANA | 34090722 | -25.359 | -57.62 | 2 | Auacion | -25.30344 | -57.6127 | 6.221401897 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 3.042534051 |
| 1347396 | 7435937 | ORTIZ DE GONZALEZ, NILVIA ROSSANA | 35785363 | -25.335 | -57.6 | 2 | Auacion | -25.30344 | -57.6127 | 3.734270359 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 0.614914049 |
| 3315588 | 7683012 | GALEANO FRANCO, NOELIA CONCEPCION | 20769319 | -25.367 | -57.613 | 2 | Auacion | -25.30344 | -57.6127 | 7.067613848 | 20 | Lamhure | 1 | -25.34022 | -57.59798 | 3.338447051 |

Figure 16: List of all Client Committees Included in the Analysis

Analysis of Client Committees Flow

Next, we analyzed the committees that moved to another office by making a flow analysis. This consisted of creating a From/To chart found in Figure 17.

| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|----|---|----|---|---|---|----|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 2 | 0 | 5 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 1 | 7 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 3 | 24 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 0 | 25 | 0 | 4 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 19 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 5 | 7 | 0 | 1 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Figure 17: From/To Chart of Client Committees that Moved to another Office

Figure 17 shows the amount of committees that left one office and entered another, hence the from/to concept. The bold numbers on the left represent the *From* offices and the bold numbers on the top represent the *To* offices. The table can be read as follows: 5 committees left office 2 and entered office 3. The cells highlighted in yellow show the amount of committees that moved from the respective office in the left and entered the respective office in the top row. In the table there is no number 1 because office 1 represents the headquarters of FP which does not participate in the Microfinance program. The information from the From/To chart is summarized in Table 4.

Table 4: Summary of From/To Chart for Client Committees that Moved to another Office

| Committee Flow Analysis | | | | | Current and Future Scenarios | | |
|-------------------------|----------------------|------|----|--------|------------------------------|-------|------------|
| Office # | Office Name | From | To | Stayed | Before | After | Difference |
| 2 | Asunción | 52 | 20 | 21 | 73 | 41 | -32 |
| 3 | San Lorenzo | 40 | 61 | 68 | 108 | 129 | 21 |
| 4 | Caacupé | 12 | 2 | 116 | 128 | 118 | -10 |
| 5 | Carapeguá | 3 | 10 | 98 | 101 | 108 | 7 |
| 6 | Luque | 14 | 9 | 83 | 97 | 92 | -5 |
| 7 | Villa Elisa | 35 | 43 | 34 | 69 | 77 | 8 |
| 8 | San Ignacio | 0 | 0 | 59 | 59 | 59 | 0 |
| 9 | Encarnación | 0 | 0 | 171 | 171 | 171 | 0 |
| 10 | Ciudad del Este | 1 | 0 | 138 | 139 | 138 | -1 |
| 12 | Villa Hayes | 0 | 3 | 16 | 16 | 19 | 3 |
| 13 | Mariano Roque Alonso | 10 | 15 | 75 | 85 | 90 | 5 |
| 14 | Caaguazú | 0 | 6 | 186 | 186 | 192 | 6 |
| 15 | Itá | 35 | 39 | 104 | 139 | 143 | 4 |
| 16 | Ybycui | 0 | 2 | 37 | 37 | 39 | 2 |
| 17 | Coronel Oviedo | 1 | 14 | 75 | 76 | 89 | 13 |
| 18 | Santaní | 17 | 1 | 141 | 158 | 142 | -16 |
| 19 | Paraguarí | 5 | 10 | 68 | 73 | 78 | 5 |
| 20 | Lambaré | 36 | 30 | 18 | 54 | 48 | -6 |
| 21 | Pilar | 0 | 0 | 68 | 68 | 68 | 0 |
| 22 | Villarrica | 5 | 0 | 41 | 46 | 41 | -5 |
| 23 | Concepción | 0 | 1 | 69 | 69 | 70 | 1 |
| 24 | Villa Ygatimí | 0 | 0 | 9 | 9 | 9 | 0 |
| 25 | Curuguaty | 1 | 0 | 33 | 34 | 33 | -1 |
| 26 | San Pedro | 0 | 1 | 60 | 60 | 61 | 1 |

Table 4 was done by summing up the rows and columns of the From/To chart in Figure 17. The left-hand side of the table summarizes the changing committees flow analysis. The *From* column is a result of the sum of each row and the *To* column is a result of the sum of each column. The office of Asunción was the office to lose the most committees (52). On the other hand, the office of San Lorenzo was the one to gain most committees (61). The office of Caaguazu was the office in which the most committees did not change (186). It was also one of the nine offices that did not lose any client committees; this is largely because of its remote location with respect to the other offices.

The right-hand side of Table 4 summarizes the *Before* and *After* reassignment scenarios for each office. The *Before* column shows the amount of committees for each office before the reassignment and consists of the sum of the *From* and *Stayed* columns. The *After* column shows the amount of committees for each office after the reassignment and is a result of the sum of the *To* and *Stayed* columns. The *Difference* column shows whether offices ended up gaining or losing loans and the ones that lost are highlighted in pink.

Analysis of Loan Amount Flow

We did the same flow analysis with loans in dollars. The From/To chart in Figure 18 shows the sum of the loans moving from one office to another. This information is summarized in Table 5.

| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|----|----------|-----------|---------|----------|----------|-----------|-----|-----|-----|---------|----------|----------|-----------|----------|-----|---------|----------|-----------|---------|-----|---------|-----|---------|-----|-----|
| 2 | \$0 | \$35,995 | \$0 | \$0 | \$0 | \$137,259 | \$0 | \$0 | \$0 | \$0 | \$21,009 | \$0 | \$7,855 | \$0 | \$0 | \$0 | \$0 | \$167,453 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 3 | \$0 | \$0 | \$0 | \$3,095 | \$33,235 | \$37,683 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$147,690 | \$0 | \$0 | \$0 | \$0 | \$0 | \$2,770 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 4 | \$0 | \$0 | \$0 | \$0 | \$11,768 | \$0 | \$0 | \$0 | \$0 | \$7,944 | \$0 | \$0 | \$7,735 | \$0 | \$0 | \$0 | \$43,114 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 5 | \$13,419 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$5,678 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 6 | \$0 | \$0 | \$5,570 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$91,717 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 7 | \$10,850 | \$102,587 | \$0 | \$7,390 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$17,605 | \$0 | \$0 | \$0 | \$0 | \$22,533 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 8 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 9 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 10 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$4,870 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 11 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 12 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 13 | \$30,655 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$6,333 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 14 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 15 | \$0 | \$159,285 | \$0 | \$16,756 | \$0 | \$23,196 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$10,299 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 16 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 17 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$3,464 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 18 | \$2,881 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$75,320 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$4,183 | \$0 | \$3,428 | \$0 | \$0 |
| 19 | \$1,129 | \$0 | \$0 | \$13,118 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$3,296 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 20 | \$17,603 | \$40,646 | \$0 | \$9,255 | \$0 | \$74,491 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$42,101 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 21 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 22 | \$3,956 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$11,370 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 23 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 24 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 25 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$3,212 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| 26 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |

Figure 18: From/To Chart of Loan Amounts Pertaining to Client Committees that Moved to another Office

Figure 18 shows the loan amounts that left one office and entered another, hence the From/To concept. The bold numbers on the left represent the *From* offices and the bold numbers on the top represent the *To* offices. The table can be read as follows: \$35,995 total of loan amount left office 2 and entered office 3. The cells highlighted in yellow show the amount of committees that moved from the respective office in the left and entered the respective office in the top row. Table 5 summarizes the From/To Chart in Figure 18.

Table 5: Summary of From/To Chart of Loan Amounts Pertaining to Client Committees that Moved to another Office

| Loan Flow Analysis | | | | Current and Future Scenarios | | | |
|--------------------|----------------------|-----------|-----------|------------------------------|-------------|-------------|------------|
| Office # | Office | From | To | Stayed | Before | After | Difference |
| 2 | Asunción | \$369,570 | \$80,492 | \$162,992 | \$532,562 | \$243,484 | -\$289,079 |
| 3 | San Lorenzo | \$224,473 | \$338,512 | \$395,647 | \$620,121 | \$734,160 | \$114,039 |
| 4 | Caacupé | \$70,560 | \$5,570 | \$730,909 | \$801,470 | \$736,479 | -\$64,991 |
| 5 | Carapeguá | \$19,097 | \$49,614 | \$538,833 | \$557,929 | \$588,446 | \$30,517 |
| 6 | Luque | \$97,287 | \$45,003 | \$497,887 | \$595,174 | \$542,890 | -\$52,284 |
| 7 | Villa Elisa | \$160,964 | \$272,629 | \$222,984 | \$383,948 | \$495,613 | \$111,665 |
| 8 | San Ignacio | \$0 | \$0 | \$251,912 | \$251,912 | \$251,912 | \$0 |
| 9 | Encarnación | \$0 | \$0 | \$1,060,692 | \$1,060,692 | \$1,060,692 | \$0 |
| 10 | Ciudad del Este | \$4,870 | \$0 | \$696,118 | \$700,988 | \$696,118 | -\$4,870 |
| 12 | Villa Hayes | \$0 | \$14,277 | \$45,330 | \$45,330 | \$59,607 | \$14,277 |
| 13 | Mariano Roque Alonso | \$36,988 | \$112,726 | \$358,417 | \$395,406 | \$471,143 | \$75,738 |
| 14 | Caaguazú | \$0 | \$19,704 | \$909,935 | \$909,935 | \$929,639 | \$19,704 |
| 15 | Itá | \$209,535 | \$226,281 | \$527,898 | \$737,433 | \$754,179 | \$16,746 |
| 16 | Ybycui | \$0 | \$5,678 | \$137,008 | \$137,008 | \$142,686 | \$5,678 |
| 17 | Coronel Oviedo | \$3,464 | \$75,320 | \$323,132 | \$326,596 | \$398,452 | \$71,856 |
| 18 | Santaní | \$85,813 | \$3,212 | \$583,370 | \$669,182 | \$586,582 | -\$82,601 |
| 19 | Paraguarí | \$17,542 | \$53,413 | \$352,820 | \$370,362 | \$406,232 | \$35,870 |
| 20 | Lambaré | \$184,096 | \$192,756 | \$124,169 | \$308,265 | \$316,926 | \$8,660 |
| 21 | Pilar | \$0 | \$0 | \$209,551 | \$209,551 | \$209,551 | \$0 |
| 22 | Villarrica | \$15,326 | \$0 | \$133,788 | \$149,114 | \$133,788 | -\$15,326 |
| 23 | Concepción | \$0 | \$4,183 | \$313,796 | \$313,796 | \$317,979 | \$4,183 |
| 24 | Villa Ygatimí | \$0 | \$0 | \$22,225 | \$22,225 | \$22,225 | \$0 |
| 25 | Curuguaty | \$3,212 | \$0 | \$124,543 | \$127,755 | \$124,543 | -\$3,212 |
| 26 | San Pedro | \$0 | \$3,428 | \$229,853 | \$229,853 | \$233,281 | \$3,428 |

The calculations for Table 5 were done in the same way as with Table 4. The office that lost the highest loan amount was Asunción (\$369,570) which also corresponds to the office that lost the most committees. The office that gained the highest loan amount was San Lorenzo (\$338,512) which corresponds to the office that gained the most committees. The office that retained the highest loan amount was Encarnación (\$1,060,692). Ten offices did not lose any loans, and eight offices did not gain any loans. The last columns on the right show the impact of the change.

The right-hand side of Table 4 summarizes the *Before* and *After* reassignment scenarios for each office. The *Before* column shows the loan amounts for each office before the reassignment and consists of the sum of the *From* and *Stayed* columns. The *After* column shows the loan amounts for each office after the reassignment, and is a result of the sum of the *To* and *Stayed* columns. The *Difference* column shows whether offices ended up gaining or losing loans and the ones that lost are highlighted in pink.

Summary of Analysis

We analyzed 2,055 client committees which represents around 32,880 individual clients in all of Paraguay, with a loan total of \$10,456,607 as shown in

Table 6. The amount of committees that changed was 267, which represents around 4,272 individual clients and 13% of the total amount analyzed. The loan amount that changed was \$1,502,798, representing 14% of the total loans analyzed. These, along with other key figures, are summarized in Table 7. If all of the committees were inside their office's geographical limits, the total distance from offices to committees would be reduced by **2,418 miles**.

Table 6: Total Amount of Committees and Loans Analyzed

| | Amount of Committees | Loan Amount |
|-----------------------|---|--------------|
| Total Analyzed | 2,055 (approx. 32,880 individual clients) | \$10,456,607 |

Table 7: Summary of Analysis of Reassignment of Client Committees

| | | From | To | Stayed |
|-------------------|-----------------------------|--------------------------------|--------------------------------|-----------------------------------|
| Committees | Number of Committees | 267 (4,272 individual clients) | 267 (4,272 individual clients) | 1,788 (28,608 individual clients) |
| | % of Total Analyzed | 13% | 13% | 87% |
| | Maximum | 52 | 61 | 186 |
| | Minimum | 1 | 1 | 9 |
| | Average | 10.68 | 10.68 | 71.52 |
| Loans | Loan Size | \$1,502,798 | \$1,502,798 | \$8,953,809 |
| | % of Total Analyzed | 14% | 14% | 86% |
| | Maximum | \$369,570 | \$338,512 | \$1,060,692 |
| | Minimum | \$3,212 | \$3,212 | \$22,225 |
| | Average | \$60,112 | \$60,112 | \$358,152 |

Decision Making Tool

After we analyzed the impact of changing committees from one office to another, we created a summary report for each office. An example is shown in Figure 19. Each report serves as a decision making tool as it allows the managers of FP to make decisions on a case by case scenario. Each report includes client information, the loan size, its status (outgoing, incoming, or no change), its distance to the office being reported, and a suggestion. It also includes a summary that counts the number of committees and the loan sizes that are incoming, outgoing, and not changing. It also calculates the before and after

scenarios and its difference. We also included a tool for FP managers to perform a sensitivity analysis. This allows managers to determine a high loan amount to identify valuable clients. Based on that input, the cell on the suggestion column will say *Reconsider*. In Figure 19 **Error! Reference source not found.**, the rows of the client committees that meet this criteria are highlighted in yellow.

San Lorenzo Office Executive Summary

| | Total Committees | Total Loan Amount |
|------------|------------------|-------------------|
| Incoming | 61 | \$ 338,512.33 |
| Outgoing | 40 | \$ 224,473.38 |
| No Change | 68 | \$ 395,647.21 |
| Before | 108 | \$ 620,120.60 |
| After | 129 | \$ 734,159.55 |
| Difference | 21 | \$ 114,038.95 |

| Sensitivity Analysis | |
|----------------------|-------------|
| High Loan Amount | \$ 9,000.00 |
| Maximum Distance | 6.59 |

| Client ID | FP ID | Client Name | Loan Amount | Status | Distance to Office (mi) | Suggestion |
|-----------|---------|-----------------------------------|--------------|----------|-------------------------|------------|
| 874336 | 7558594 | VERA RUIZ DIAZ, MARIA BEATRIZ | \$ 3,143.76 | Incoming | 0.31 | |
| 4093217 | 7756568 | VILLALBA ROJAS, GRACIELA SOLEDAD | \$ 3,783.15 | Incoming | 4.39 | |
| 4025981 | 7566229 | ZALAZAR ESPINOZA, AGRIPINA | \$ 2,971.78 | Incoming | 4.53 | |
| 5536953 | 7779072 | ACHAR CHAPARRO, LISANDRI AMADA | \$ 12,134.98 | Outgoing | 7.56 | Reconsider |
| 1723399 | 7651977 | ADORNO MOREL, CARMEN MIGUELA | \$ 10,527.66 | Outgoing | 9.49 | Reconsider |
| 430945 | 7527424 | ARANDA DE CANTERO, EDITH ROGELIA | \$ 3,331.28 | Outgoing | 10.51 | |
| 3221848 | 7617295 | BARRETO LOPEZ, CARMEN | \$ 12,531.41 | Outgoing | 9.95 | Reconsider |
| 2237802 | 7636094 | BENITEZ FLECHA, FELICIANA | \$ 1,000.33 | Outgoing | 10.87 | |
| 1539460 | 7766774 | BUSTO DE MARTINEZ, MARIA STELA | \$ 2,584.82 | Outgoing | 5.16 | |
| 4218626 | 7763352 | CENTURION GIMENEZ, NOELIA SUSANA | \$ 2,965.22 | Outgoing | 2.66 | |
| 1949323 | 7795324 | CORRALES DE DUPUY, EUGENIA | \$ 2,752.49 | Outgoing | 9.74 | |
| 4985129 | 7787377 | DUARTE ALMADA, VERONICA LUCIA | \$ 4,357.77 | Outgoing | 5.73 | |
| 4506999 | 7597855 | ESPINOLA GONZALEZ, ALBA CECILIA | \$ 1,515.21 | Outgoing | 7.78 | |
| 2233944 | 7568216 | ESPINOLA PEREIRA, GLADYS ZUNILDA | \$ 16,672.84 | Outgoing | 5.82 | Reconsider |
| 4416778 | 7774952 | FERNANDEZ BOGARIN, ANDREA AVELINA | \$ 2,966.04 | Outgoing | 6.69 | |

Figure 19: Example of Summary Report of Reassignment of Client Committees for an Office

Implementation Plan

For the implementation of this deliverable, we provided an info packet on how to use the decision making tool and the excel worksheets with the analysis effectively and explained the different areas of the analysis. In our Skype conference call with FP managers we discussed how they should use each tab.

In our step-by-step guide on how to reproduce this analysis, we provided FP with three Excel workbooks: the ray casting workbook, the polygon coordinates workbook, and the analysis workbook. The guide also includes how to use these workbooks in order to use Ray Casting to reassign client committees, use the output of Ray Casting to create a master list of all the client committees and their current and future scenarios, and how to use the master list to reproduce the analysis we made.

Implications

This analysis allows FP managers to make decisions and know which committees they need to change. As stated, if all the committees were inside their offices' geographical limits, the total distance

would be reduced by 2,418 miles. This change could have a huge impact on the organization's transportation costs and could potentially allow them to reach a larger number of client committees. When we traveled to Paraguay, however, we saw that there was resistance to change from asesores and client committees. Asesores do not want their client committees to change because they receive a commission for each committee based on their respective loan amount. Furthermore, asesores develop a relationship of trust with their client committees which they do not wish to lose. As we learned during our visit, many client committees do not wish to have their asesor or office change because they are already used to that asesor and the way they work. For this reason, our decision making tool will allow managers to make more individual decisions in cases where there is more resistance. In terms of changing client committees from one office to another, FP is willing to risk losing client committees as well as asesores that do not want to adapt to the change.

5. Conclusions

The goal of our project was to improve the efficiency of Fundación Paraguaya's Microfinance and Poverty Stoplight Programs by implementing Industrial Engineering techniques. Our project focused on two main challenges: an individual challenge and an organizational challenge. The individual challenge was the lack of efficient planning of meetings by asesores, which we addressed by creating an optimization based scheduling tool that makes the scheduling process for meetings more efficient. The tool groups meetings based on proximity, therefore minimizing the distance asesores travel to their meetings. This tool will be used by 74 asesores in FP on a weekly basis. We calculated the impact of the scheduling tool based on the comparison between ten schedules followed by asesores and the same schedules optimized by our tool. Based on these results, the use of the tool has the potential to decrease the distance traveled by 19.92%. In one office, the distance traveled was reduced by 50.6%.

The organizational challenge was the lack of zoning of FP client committees, which we addressed by modeling the assignment of client committees to offices based on their geographical location and the analyzing the impact of these changes. This analysis will be used by FP managers to determine which client committees they should reassign to other offices to decrease the distance traveled by asesores. If all the reassignments were to be made, the total distance between client committees and offices would be reduced by 2,418 miles. We analyzed 2,055 client committees which represents around 32,880 individual clients in all of Paraguay, with a total loan amount of \$10,456,607. The amount of committees that moved from their respective office was 267, which represents around 4,272 individual clients and 13% of the total amount analyzed. The loan amount that moved from one office to another was \$1,502,798, representing 14% of the total loans analyzed. In addition we provided FP a report for each office which serves as a decision making tool. This decision making tool allows the managers of FP to make decisions on a case by case scenario. Managers will have to determine a high loan amount and an extra distance they are willing to travel outside of the office's limits for a valuable client in order to reconsider those valuable clients that are being suggested to leave the office based on location.

There are limitations to the solutions we delivered to FP. While our scheduling tool has the advantage of optimally clustering client meetings, in its present version 30 is a realistic limit on the number of client committees that can be scheduled at a single time. Due to the solving time of two minutes we imposed to the model, if 30 clients or more were to be scheduled, the solution may not be optimal. FP asesores, however, do not plan so far ahead and will most likely plan for no more than one week at a time. Another limitation is that the model calculates the distances using Manhattan distance and geographical coordinates, which does not account for roads and traffic conditions. However, we believe this will not affect most of the schedules generated. In terms of the analysis we delivered, a limitation is that the methods we used included a lot of steps which makes it more difficult for FP managers to

reproduce the analysis. Furthermore, if another office's zone were to be added to the analysis, the analysis would have to be done again. Future studies should consider creating a more visual output for the scheduling tool such as connecting it with Google Maps and showing the different groups of meetings. Another idea could be to allow the user to look at the output and decide whether they would prefer putting certain meetings together based on personal preference or client availability and then solve the schedule again.

We recommend FP to start implementing the tool gradually in two to three offices located in the metropolitan area. In this manner, they can gain feedback from the asesores with respect to how the tool improves their efficiency. From there, the tool may be adapted, as necessary, to better meet the needs of asesores. We recommend asesores use the tool to schedule between three and five days and up to twenty clients which makes up a week of work. This will ensure that the solution obtained is optimal. When we traveled to Paraguay, we saw that some asesores did not have Excel in their computers, which is necessary to run the scheduling tool. Administration assured that a way would be provided to grant them access. If this is not possible, asesores can use their managers' computers to create their schedules. We also suggest that FP sets up a remote server with Excel and OpenSolver where asesores can log in to run the scheduling tool. In terms of the analysis of reassignment of client committees, we recommend to use the individual offices' summary reports to make decisions. This will allow them to take a closer look at the clients that are moving from one office to another as well as their loan sizes and distance to the respective office. In this way, they can make a more personalized decision and look out for the interests of both asesores and clients.

We would like to continue developing our scheduling tool by staying in contact with FP managers. Due to the limited timeframe of this MQP, we were not able to see our tool being implemented prior to the project completion. We are interested in seeing how asesores react to the tool and the impact it has on their work. Both of us are interested in doing work beyond our project and use their feedback after they implement it to make the tool better.

6. Reflections

Throughout our project, we faced many challenges that we overcame mostly by showing flexibility to adapt. The challenges include working remotely from a different country, technological barriers with different regional settings, cultural challenges, learning VBA, OpenSolver, and readjusting to different projects. We believe these challenges helped us better prepare for our future careers as well as made us more interested in working for the humanitarian sector.

Working Remotely from a Different Country

Throughout our project, we overcame many obstacles, many of which arose from us and our sponsor being in different countries. Before we began our project, both of us along with one of our advisors Prof. Andrew Trapp, traveled to Asunción, Paraguay to define our project. Even though we had to miss out on a few vacation days, this trip was worth it because we were able to really understand the challenges Fundación Paraguaya was facing and wanted to address with our project. Before we left Paraguay, we had a clear idea of a starting point for our project: the scheduling tool for asesores. After we returned to WPI and started working on our project, we started facing challenges such as not being able to set weekly Skype meetings, not being able to test our tool on their computers with any frequency, and not receiving feedback for continuous improvement. Furthermore, even as we specified that we only had four months to work on our project, the workers at Fundación Paraguaya were not used to the fast-paced working environment at WPI. This slowed our pace from time to time, but we made sure to remain productive and tried to work ahead of time. There was also miscommunication with our liaison mostly during our second deliverable, as we were receiving many different heavy files and had to repeat the same processes over and over with all of them. It took us around a week to be on the same page regarding those files. At the beginning of our project, we struggled to establish the way we could communicate with our liaison. Even though we wanted to have weekly Skype meetings and communicate via email, this was not always the case. To overcome this, we tried different methods to determine the most comfortable mode of communication with Fundación Paraguaya. Eventually, we communicated through WhatsApp, an instant messaging application, and we were able to ask questions and receive answers almost instantly in most cases. Even though this was unconventional, our team had to adapt to advance in our project and ensure open communication.

Technological Barriers with Regional Settings

Another major challenge was the technological barrier and the differences in computer systems. We first built our model in English and all the coding was done in English. When we translated everything to Spanish, we faced more challenges than we had imagined. First, latitude and longitude coordinates varied in their format, as some of them would have periods and some of them would have

commas. Coordinates were essential to our model because we were clustering client committees based on distances between them. This challenge, forced us to give a lot of thought on how we would clean the coordinates and ensure that no matter the format the coordinates were input into our model, we could format them in a uniform way. Another challenge was date filtering. We wanted to include a feature that allowed them to visually filter their client committees by date to suggest the client committees they should meet with. This feature worked perfectly when regional settings were in English, but it did not work when they were in Spanish. We tried many different ways to make it work but in the end decided that it was not a good idea to keep spending so much time on it. Another minor challenge was some formulas in the code for Visual Basic for Applications did not translate to Spanish settings. This was a quick fix but we had already spent so much time troubleshooting for small details related to language settings, that we were discouraged. We, however, were able to overcome all these challenges trying to address these problems from different angles, pulling resources from different places, and knowing when to give up. It also helped that our liaison in Paraguay had experience working with Excel.

Cultural Challenges

We decided to work on this project because both of us wanted to gain experience in using Industrial Engineering methods to solve problems in the humanitarian sector. For this reason, working with Martin Burt's Fundación Paraguaya seemed like a perfect fit for our Major Qualifying Project. In our Reflections Section, we mentioned some of the challenges we encountered during our project, which included the difficulty of working from another country and the challenges related to incorporating into the solutions proposed. These challenges, however, enabled us to gain insight and learn how to solve problems in similar scenarios. Before we went to Paraguay, we had discussed that we were not coming in to solve FP's problems, rather we were going to listen to different FP workers and understand the challenges from their perspectives. Using this mindset, we were able to bring those perspectives into the solution we created.

Learning New Technology: VBA

Another major challenge was learning a computer language from scratch. When we decided we wanted to conduct our MQP using Optimization as the main tool, which we had experience working with, we were not aware we will have to learn a whole new computer language to execute our project. After we went to Paraguay we understood we were not only creating an optimization model to solve a problem but a flexible tool that can accommodate to the number of client committees and days the asesores determine when they use it. Therefore, Visual Basic for Applications (VBA) became relevant in our project. It was definitely a challenge to learn VBA while completing the other parts of the project but with hours of hard work, we were able to grasp the main concepts and functionalities of the language. By the end of the project we were able to write pieces of code without referring to other parts of the code, we understood

the language and its functionalities. We discovered the power of VBA and included userforms in our Excel tool as well as many dynamic macros that ease the use of the tool. Something that was key for our team was that both of the team members learned to use VBA, therefore when one had a problem the other one helped debugging it. This accelerated the process for the VBA portion of the project to be completed.

Learning Rapidly Evolving Technology: OpenSolver

For the development of our optimization tool, we used OpenSolver which is a replacement of Excel's built-in Solver with open-source technology. Excel's Solver allows you to find an optimal maximum or minimum in one cell in Excel subject to constraints that are placed in other cells in Excel. OpenSolver was developed and is currently maintained by Andrew Mason and students at the Engineering Science department of University of Auckland in New Zealand (Mason 2012). OpenSolver keeps being upgraded and problems are regularly posted on the web page and solved on a day-to-day basis. Due to its constant change nature, we had developed our VBA code to use OpenSolver in a version similar to what other projects had used. As mentioned before, many things became problems once we opened the tool in another country including OpenSolver. Through looking on their webpage we found there was a global way to use OpenSolver in VBA. We updated our VBA code to the newest version we found and everything worked perfectly. It is a great advantage that OpenSolver keeps being upgraded but it's a challenge because it requires whoever is using it to keep checking if the problems he encounters are mentioned and solved on the webpage.

Adjusting to a Changing Project Scope

In addition, another challenge we experienced throughout our project was a change of direction in our second project, the redistribution of client committees in new zones. We were planning to use the database of client committees, and using the coordinates of the offices, we were going to determine new zones for each office based on the proximity of client committees and the density of client committees each office had using optimization techniques. Nevertheless, when we started the meetings to discuss this part of the project we were notified that the zones were already determined by Fundación Paraguaya officers and that our task was to assign them to the offices they were going to fall in according to their geographical location and develop and analysis of the impact of these changes. We had to adjust to this new situation and make a plan to determine how we were going to address this new project. We came up with a solution after much thought and we implemented a technique called Ray Casting to assign client committees to offices geographically and then we created a from-to chart analysis to determine the flow of client committees in each office.

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Appendix A: Modifications Made to Model (1.1)-(1.6) to Achieve Linearity

1. Replace the Euclidean distance formula $\sqrt{(x^c - x_k)^2 + (y^c - y_k)^2}$ with $|x^c - x_k| + |y^c - y_k|$ for all client committees c and cluster centers k . x^c and y^c refer to given coordinates and x_k and y_k refer to variables that represent cluster center coordinates.
2. Set the constraint of $d_k^c \geq (x_k^{c+} + x_k^{c-} + y_k^{c+} + y_k^{c-}) - M_c * (1 - z_k^c)$ for all x and all k . d_k^c are decision variables that express the distance between point c and center k when assigned, respectively. M_c is a large number, and z_k^c is the variable that states whether a point was assigned to a cluster or not.
3. Substitute $|x^c - x_k| + |y^c - y_k|$ with $x_k^{c+}, x_k^{c-}, y_k^{c+}, y_k^{c-}$ subject to $\ell^c - \ell_k = x_k^{c+} - x_k^{c-}$ and $n^c - n_k = y_k^{c+} - y_k^{c-} \forall c, \forall k$. All, $x_k^{c+}, x_k^{c-}, y_k^{c+}, y_k^{c-}$ are variables.

Appendix B: Visual Basic for Applications Code

Scheduling Tool Model Code

This code enables the tool to create the optimization model that clusters selected meetings based on proximity.

```
Private Sub Ok_Click()
```

```
'Prompts worker with a message if he or she did not specify the number of days
```

```
    If TextBox1.Value = "" Then
```

```
        MsgBox ("Necesita determinar el numero de días")
```

```
    ElseIf IsNumeric(TextBox1) Then
```

```
        Sheets("Configuración").Range("C8").Value = TextBox1.Text
```

```
    End If
```

```
'Determine the number of selected clients
```

```
    Dim NumClients As Integer
```

```
    NumClients = Sheets("Configuracion").Cells(10, 3)
```

```
'Determine the number of clusters
```

```
    Dim NumClusters As Integer
```

```
    NumClusters = Sheets("Configuracion").Cells(8, 3)
```

```
'Determine the minimum number of clients assigned per cluster
```

```
    Dim MinClients As Integer
```

```
    MinClients = Sheets("Configuracion").Cells(4, 3)
```

```
'Determine the maximum number of clients assigned per cluster
```

```
    Dim MaxClients As Integer
```

```
    MaxClients = Sheets("Configuracion").Cells(5, 3)
```

```
'Tests whether the amount of days to plan is too much for the amount of clients selected
```

```

If NumClients / NumClusters < MinClients Then

    MsgBox "Reduzca el número permitido de reuniones por día en la pestaña llamada
    ""Configuración"" o cree el horario para menos días"

'Tests whether the amount of days to plan is enough for the amount of clients selected

    ElseIf NumClients / NumClusters > MaxClients Then

        MsgBox "Aumente el número permitido de reuniones por día en la pestaña llamada
        ""Configuración"" o cree el horario para mas días"

    Else

        Unload Me

'Turn off screen updating while performing tasks

    Application.ScreenUpdating = False

Formulas of "Configuración" tab

    Worksheets("Configuracion").Activate

    Cells(10, 3).Formula = "=Counta(ClientesSeleccionados!" & Range("A:A").Address & ")-1"

    Cells(9, 3).Formula = "=Counta(BaseDeDatos!" & Range("A:A").Address & ")-1"

'Determine value of skip

    Dim skip As Integer

    skip = 1

'Determine the maximum time assigned per cluster

    Dim MaxTime As Integer

    MaxTime = Sheets("Configuracion").Cells(6, 3)

'Determine r as c as integers

    Dim r As Integer

    Dim c As Integer

'Determine the number of clients in the database

```



```

Dim BaseDeDatos As Integer

BaseDeDatos = Sheets("Configuracion").Cells(9, 3)

'Lookup coordinates by ID in "BaseDeDatos"

Worksheets("ClientesSeleccionados").Activate

For r = 2 To 1 + NumClients

    Cells(r, 2).Formula = "=VLOOKUP(" & Cells(r, 1).Address & ", BaseDeDatos!" & Range(Cells(2, 1), Cells(BaseDeDatos + 1, 4)).Address & ", ""2"", FALSE)"

Next r

For r = 2 To 1 + NumClients

    Cells(r, 3).Formula = "=VLOOKUP(" & Cells(r, 1).Address & ", BaseDeDatos!" & Range(Cells(2, 1), Cells(BaseDeDatos + 1, 4)).Address & ", ""3"", FALSE)"

Next r

For r = 2 To 1 + NumClients

    Cells(r, 4).Formula = "=VLOOKUP(" & Cells(r, 1).Address & ", BaseDeDatos!" & Range(Cells(2, 1), Cells(BaseDeDatos + 1, 4)).Address & ", ""4"", FALSE)"

Next r

'Clean coordinates data

Worksheets("ClientesSeleccionados").Activate

For r = 2 To 1 + NumClients

    For c = 15 To 16

        Range(Cells(2, 3), Cells(1 + NumClients, 4)).Select

        Selection.Copy

        Cells(2, 13).Select

        Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _

        :=False, Transpose:=False

```

```

Selection.Replace What:=".", Replacement:="", LookAt:=xlPart, _
    SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
    ReplaceFormat:=False
Selection.Replace What:=",", Replacement:="", LookAt:=xlPart, _
    SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
    ReplaceFormat:=False

Cells(r, c).Formula = "=1*(If(Len(" & Cells(r, c - 2).Address & ")=4,Concatenate(Left(" &
Cells(r, c - 2).Address & ",4),"00"),If(Len(" & Cells(r, c - 2).Address & ")=5,Concatenate(Left(" &
Cells(r, c - 2).Address & ",5),"0"),If(Len(" & Cells(r, c - 2).Address & ")>=6,Left(" & Cells(r, c -
2).Address & ",6),"FALSE"))))"

Next c

Next r

'Hide Columns were coordinates are cleaned from ClientesSeleccionados Sheet
Columns("L:P").Select

Selection.EntireColumn.Hidden = True

'Delete any worksheet in the workbook named "HorarioPreliminar"

Dim WS2 As Worksheet

For Each WS2 In Worksheets

    If WS2.Name = "HorarioPreliminar" Then

        Application.DisplayAlerts = False

        Sheets("HorarioPreliminar").Delete

        Application.DisplayAlerts = True

    End If

Next

'Add new output sheet

```

```

Sheets.Add.Name = "HorarioPreliminar"

'Add new optimization model sheet

Sheets.Add.Name = "New_Model"

'Create column with the time for each meeting

For r = 8 + 2 * (NumClients + skip) To 6 + 3 * (NumClients + skip)

    For c = 6 To 6

        Cells(r, c).Value = Sheets("ClientesSeleccionados").Cells(r - 8 - 2 * NumClients, c - 1)

    Next c

Next r

'Create Table for Solver Parameters

Cells(10 + 3 * (NumClients + skip), 2).Value = "passF"

Cells(10 + 3 * (NumClients + skip), 3).Value = 1000

Cells(11 + 3 * (NumClients + skip), 2).Value = "preprocess"

Cells(11 + 3 * (NumClients + skip), 3).Value = "on"

'Create table for binary variables (assignments to each cluster)

For r = 1 To 1

    Cells(r, 1).Value = 1

Next r

For r = 2 To NumClients + 1

    For c = 2 To NumClusters + 1

        Cells(r, c).Value = 0

    Next c

Next r

'Create table for x+ variable

```

```

For r = 2 To NumClients + 1

    For c = (2 + NumClusters + skip) To 2 * (NumClusters + skip)

        Cells(r, c).Value = 0

    Next c

Next r

'Create table for x-variable

For r = 2 To NumClients + 1

    For c = (2 + (2 * (NumClusters + skip))) To 3 * (NumClusters + skip)

        Cells(r, c).Value = 0

    Next c

Next r

'Create table for y+ variable

For r = 2 To NumClients + 1

    For c = (2 + (3 * (NumClusters + skip))) To 4 * (NumClusters + skip)

        Cells(r, c).Value = 0

    Next c

Next r

'Create table for y- variable

For r = 2 To NumClients + 1

    For c = (2 + (4 * (NumClusters + skip))) To 5 * (NumClusters + skip)

        Cells(r, c).Value = 0

    Next c

Next r

'Create table for dpk

```

```

For r = 2 To NumClients + 1

    For c = (2 + (5 * (NumClusters + skip))) To 6 * (NumClusters + skip)

        Cells(r, c).Value = 0

    Next c

Next r

'Create cell for objective value

For r = 8 + 2 * (NumClients + skip) To 8 + 2 * (NumClients + skip)

    For c = 2 + 2 * (NumClusters + skip) To 2 + 2 * (NumClusters + skip)

        Cells(r, c).Formula = "=sum(" & Cells(r - 6 - 2 * (NumClients + skip), c + 3 * (NumClusters + skip)).Address & ":" & Cells(r - 9 - NumClients, c - 2 + 4 * (NumClusters + skip)).Address & ")"

    Next c

Next

'Create cell to insert "0" needed for constraints

For r = 8 + 2 * (NumClients + skip) To 8 + 2 * (NumClients + skip)

    For c = 3 + 2 * (NumClusters + skip) To 3 + 2 * (NumClusters + skip)

        Cells(r, c).Value = 0

    Next c

Next r

'Create column for assignment of all constraint (=sum)

Dim RowShift As Integer

RowShift = NumClients + 1

For r = 2 + NumClients + skip To 2 * (NumClients + skip)

    Cells(r, 2).Formula = "=sum(" & Cells(r - RowShift, 2).Address & ":" & Cells(r - RowShift, 1 + NumClusters).Address & ")"

Next r

```

'Create column for equal sign of constraint of assigning all

For r = 2 + NumClients + skip To 2 * (NumClients + skip)

For c = 3 To 3

Cells(r, c).Value = "="

Next c

Next r

'Create column for constraint of assigning all(=1)

For r = 2 + NumClients + skip To 2 * (NumClients + skip)

For c = 4 To 4

Cells(r, c).Value = 1

Next c

Next r

'Create table for xc-xk

For r = 2 + NumClients + skip To 2 * (NumClients + skip)

For c = (2 + NumClusters + skip) To 2 * (NumClusters + skip)

Cells(r, c).Formula = "=" & Cells(r + 7 + NumClients, 2).Address & "-" & Cells(4 + 2 * (NumClients + skip), c).Address & ")"

Next c

Next r

'Create table for x+-x-

For r = 2 + NumClients + skip To 2 * (NumClients + skip)

For c = (2 + (2 * (NumClusters + skip))) To 3 * (NumClusters + skip)

Cells(r, c).Formula = "=" & Cells(r - RowShift, c - NumClusters - skip).Address & "-" & Cells(r - RowShift, c).Address & ")"

Next c

Next r

'Create table for yc-yk

For r = 2 + NumClients + skip To 2 * (NumClients + skip)

For c = (2 + (3 * (NumClusters + skip))) To 4 * (NumClusters + skip)

Cells(r, c).Formula = "=" & Cells(r + 7 + NumClients, 3).Address & "-" & Cells(4 + 2 * (NumClients + skip), c - NumClusters - skip).Address & ")"

Next c

Next r

'Create table for y+-y-

For r = 2 + NumClients + skip To 2 * (NumClients + skip)

For c = (2 + (4 * (NumClusters + skip))) To 5 * (NumClusters + skip)

Cells(r, c).Formula = "=" & Cells(r - RowShift, c - NumClusters - skip).Address & "-" & Cells(r - RowShift, c).Address & ")"

Next c

Next r

'Create table for Dpk constraint

For r = 2 + NumClients + skip To 2 * (NumClients + skip)

For c = (2 + (5 * (NumClusters + skip))) To 6 * (NumClusters + skip)

Cells(r, c).Formula = "=" & Cells(r - RowShift, c - 4 * (NumClusters + skip)).Address & "+" & Cells(r - RowShift, c - 3 * (NumClusters + skip)).Address & "+" & Cells(r - RowShift, c - 2 * (NumClusters + skip)).Address & "+" & Cells(r - RowShift, c - NumClusters - skip).Address & "-" & Cells(r, 2 + 6 * (NumClusters + skip)).Address & "*" & Cells(1, 1).Address & "-" & Cells(r - skip - NumClients, c - 5 * (NumClusters + skip)).Address & ")"

Next c

Next r

'Create column for Mp constraint

For r = 2 + NumClients + skip To 2 * (NumClients + skip)

For c = 2 + 6 * (NumClusters + skip) To 2 + 6 * (NumClusters + skip)

Cells(r, c).Formula = "=max(abs(" & Cells(8 + 2 * (NumClients + skip), 4).Address & "-" & Cells(r + 7 + NumClients, 2).Address & "),abs(" & Cells(9 + 2 * (NumClients + skip), 4).Address & "-" & Cells(r + 7 + NumClients, 2).Address & ")))+max(abs(" & Cells(8 + 2 * (NumClients + skip), 5).Address & "-" & Cells(r + 7 + NumClients, 3).Address & "),abs(" & Cells(9 + 2 * (NumClients + skip), 5).Address & "-" & Cells(r + 7 + NumClients, 3).Address & "))"

Next c

Next r

'Create table for the sum of meeting time of meetings assigned to each cluster

For r = 2 + NumClients + skip To 2 * (NumClients + skip)

For c = 4 + 6 * (NumClusters + skip) To 7 * (NumClusters + skip) + 2

Cells(r, c).Formula = "=" & Cells(r + NumClients + 7, 6).Address & "*" & Cells(r - NumClients - skip, c - 2 - 6 * (NumClusters + skip)).Address & ")"

Next c

Next r

'Create row for sum of time of all meetings assigned to each cluster

For r = 2 * (NumClients + skip) + 1 To 2 * (NumClients + skip) + 1

For c = 4 + 6 * (NumClusters + skip) To 7 * (NumClusters + skip) + 2

Cells(r, c).Formula = "=sum(" & Cells(2 + NumClients + skip, c).Address & ":" & Cells(2 * (NumClients + skip), c).Address & ")"

Next c

Next r

'Create row for "<=" for the upper bound on time per cluster

For r = 2 * (NumClients + skip) + 2 * (skip) To 2 * (NumClients + skip) + 2 * (skip)

For c = 4 + 6 * (NumClusters + skip) To 7 * (NumClusters + skip) + 2


```

    Cells(r, c).Value = "<="

Next c

Next r

'Create row for upper bound on time per cluster

For r = 2 * (NumClients + skip) + 3 * (skip) To 2 * (NumClients + skip) + 3 * (skip)

    For c = 4 + 6 * (NumClusters + skip) To 7 * (NumClusters + skip) + 2

        Cells(r, c).Value = MaxTime

    Next c

Next r

'Create row for lower bound of meetings per cluster

For r = 2 + 2 * (NumClients + skip) To 2 + 2 * (NumClients + skip)

    For c = 2 To NumClusters + 1

        Cells(r, c).Value = MinClients

    Next c

Next r

'Create row for "<=" for bounds on meetings per cluster

For r = 2 + 2 * (NumClients + skip) + (skip) To 2 + 2 * (NumClients + skip) + (skip)

    For c = 2 To NumClusters + 1

        Cells(r, c).Value = "<="

    Next c

Next r

'Create row for sum of meetings per cluster

For r = 2 + 2 * (NumClients + skip) + 2 * (skip) To 2 + 2 * (NumClients + skip) + 2 * (skip)

    For c = 2 To NumClusters + 1

```

```
Cells(r, c).Formula = "=sum(" & Cells(2, c).Address & ":" & Cells(1 + NumClients, c).Address &
")"
```

```
Next c
```

```
Next r
```

```
'Create row for "<=" for bounds on meetings per cluster
```

```
For r = 2 + 2 * (NumClients + skip) + 3 * (skip) To 2 + 2 * (NumClients + skip) + 3 * (skip)
```

```
For c = 2 To NumClusters + 1
```

```
Cells(r, c).Value = "<="
```

```
Next c
```

```
Next r
```

```
'Create row for upper bound of meetings per cluster
```

```
For r = 2 + 2 * (NumClients + skip) + 4 * (skip) To 2 + 2 * (NumClients + skip) + 4 * (skip)
```

```
For c = 2 To NumClusters + 1
```

```
Cells(r, c).Value = MaxClients
```

```
Next c
```

```
Next r
```

```
'Create table for latitudes and longitudes (x and y coordinates) of selected clients
```

```
For r = 8 + 2 * (NumClients + skip) To 6 + 3 * (NumClients + skip)
```

```
For c = 2 To 3
```

```
Cells(r, c).Value = Sheets("ClientesSeleccionados").Cells(r - 8 - 2 * NumClients, c + 13)
```

```
Next c
```

```
Next r
```

```
'Create cell for the minimum out of the x coordinates with formula
```

```
Cells(8 + 2 * (NumClients + skip), 4).Formula = "=min(" & Cells(8 + 2 * (NumClients + skip),  
2).Address & ":" & Cells(6 + 3 * (NumClients + skip), 2).Address & ")"
```

'Create cell for the maximum out of the x coordinates with formula

```
Cells(9 + 2 * (NumClients + skip), 4).Formula = "=max(" & Cells(8 + 2 * (NumClients + skip),  
2).Address & ":" & Cells(7 + 3 * (NumClients + skip), 2).Address & ")"
```

'Create cell for the minimum out of the y coordinates with formula

```
Cells(8 + 2 * (NumClients + skip), 5).Formula = "=min(" & Cells(8 + 2 * (NumClients + skip),  
3).Address & ":" & Cells(6 + 3 * (NumClients + skip), 3).Address & ")"
```

'Create cell for the maximum out of the y coordinates with formula

```
Cells(9 + 2 * (NumClients + skip), 5).Formula = "=max(" & Cells(8 + 2 * (NumClients + skip),  
3).Address & ":" & Cells(7 + 3 * (NumClients + skip), 3).Address & ")"
```

'Create row for x centers variable lower bound

```
For r = 2 + 2 * (NumClients + skip) To 2 + 2 * (NumClients + skip)
```

```
For c = 2 + NumClusters + skip To 2 * (NumClusters + skip)
```

```
Cells(r, c).Value = Cells(8 + 2 * (NumClients + skip), 4)
```

```
Next c
```

```
Next r
```

'Create row for "<=" from lower bounds --> x Centers

```
For r = 3 + 2 * (NumClients + skip) To 3 + 2 * (NumClients + skip)
```

```
For c = 2 + NumClusters + skip To 2 * (NumClusters + skip)
```

```
Cells(r, c).Value = "<="
```

```
Next c
```

```
Next r
```

'Create row for x centers changing variable

```
For r = 4 + 2 * (NumClients + skip) To 4 + 2 * (NumClients + skip)
```

```
For c = 2 + NumClusters + skip To 2 * (NumClusters + skip)
```

```
Cells(r, c).Value = 0
```

Next c

Next r

'Create row for "<=" from x centers--> upper bounds

For r = 5 + 2 * (NumClients + skip) To 5 + 2 * (NumClients + skip)

For c = 2 + NumClusters + skip To 2 * (NumClusters + skip)

Cells(r, c).Value = "<="

Next c

Next r

'Create row for x centers variable upper bound

For r = 6 + 2 * (NumClients + skip) To 6 + 2 * (NumClients + skip)

For c = 2 + NumClusters + skip To 2 * (NumClusters + skip)

Cells(r, c).Value = Cells(9 + 2 * (NumClients + skip), 4)

Next c

Next r

'Create row for y centers variable lower bound

For r = 2 + 2 * (NumClients + skip) To 2 + 2 * (NumClients + skip)

For c = 2 + 2 * (NumClusters + skip) To 3 * (NumClusters + skip)

Cells(r, c).Value = Cells(8 + 2 * (NumClients + skip), 5)

Next c

Next r

'Create row for "<=" from lower bounds --> y centers

For r = 3 + 2 * (NumClients + skip) To 3 + 2 * (NumClients + skip)

For c = 2 + 2 * (NumClusters + skip) To 3 * (NumClusters + skip)

Cells(r, c).Value = "<="

Next c

Next r

'Create row for y centers changing variable

For r = 4 + 2 * (NumClients + skip) To 4 + 2 * (NumClients + skip)

For c = 2 + 2 * (NumClusters + skip) To 3 * (NumClusters + skip)

Cells(r, c).Value = 0

Next c

Next r

'Create row for "<=" from y centers--> upper bounds

For r = 5 + 2 * (NumClients + skip) To 5 + 2 * (NumClients + skip)

For c = 2 + 2 * (NumClusters + skip) To 3 * (NumClusters + skip)

Cells(r, c).Value = "<="

Next c

Next r

'Create row for y centers variable upper bound

For r = 6 + 2 * (NumClients + skip) To 6 + 2 * (NumClients + skip)

For c = 2 + 2 * (NumClusters + skip) To 3 * (NumClusters + skip)

Cells(r, c).Value = Cells(9 + 2 * (NumClients + skip), 5)

Next c

Next r

'Begin creating the optimization model for the Scheduling Tool

OpenSolver.ResetModel Sheet:=Sheets("New_Model")

'Set Objective Function

```
OpenSolver.SetObjectiveFunctionCell Sheets("New_Model").Range(Cells(8 + 2 * (NumClients + skip), 2 + 2 * (NumClusters + skip)), Cells(8 + 2 * (NumClients + skip), 2 + 2 * (NumClusters + skip))), Sheet:=Sheets("New_Model")
```

```
OpenSolver.SetObjectiveSense MinimiseObjective, Sheet:=Sheets("New_Model")
```

'Variable Definition

```
OpenSolver.SetDecisionVariables Union(Sheets("New_Model").Range(Cells(2, 2), Cells(NumClients + 1, NumClusters + 1)), Sheets("New_Model").Range(Cells(2, (2 + NumClusters + skip)), Cells(NumClients + 1, 2 * (NumClusters + skip))), Sheets("New_Model").Range(Cells(2, 2 + 2 * (NumClusters + skip)), Cells(NumClients + 1, 3 * (NumClusters + skip))), Sheets("New_Model").Range(Cells(2, 2 + 3 * (NumClusters + skip)), Cells(NumClients + 1, 4 * (NumClusters + skip))), Range(Cells(2, 2 + 4 * (NumClusters + skip)), Cells(NumClients + 1, 5 * (NumClusters + skip))), Sheets("New_Model").Range(Cells(2, 2 + 5 * (NumClusters + skip)), Cells(NumClients + 1, 6 * (NumClusters + skip))), Sheets("New_Model").Range(Cells(4 + 2 * (NumClients + skip), 2 + NumClusters + skip), Cells(4 + 2 * (NumClients + skip), 2 * (NumClusters + skip))), Sheets("New_Model").Range(Cells(4 + 2 * (NumClients + skip), 2 + 2 * (NumClusters + skip)), Cells(4 + 2 * (NumClients + skip), 3 * (NumClusters + skip)))), Sheet:=Sheets("New_Model")
```

'Constraint Binary Variables Assignment

```
OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(2, 2), Cells(NumClients + 1, NumClusters + 1)), RelationBIN, Sheet:=Sheets("New_Model")
```

'Constraint all points (clients) need to be assigned

```
OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(2 + NumClients + skip, 2), Cells(2 * (NumClients + skip), 2)), RelationEQ, Sheets("New_Model").Range(Cells(2 + NumClients + skip, 4), Cells(2 * (NumClients + skip), 4)), Sheet:=Sheets("New_Model")
```

'Constraint lower bound (amount of meetings per clusters)

```
OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(2 + 2 * (NumClients + skip), 2), Cells(2 + 2 * (NumClients + skip), NumClusters + skip)), RelationLE, Sheets("New_Model").Range(Cells(4 + 2 * (NumClients + skip), 2), Cells(4 + 2 * (NumClients + skip), NumClusters + skip)), Sheet:=Sheets("New_Model")
```

'Constraint upper bound (amount of meetings per clusters)

OpenSolver.AddConstraint New_Model.Range(), RelationLE, New_Model.Range(),
Sheet:=New_Model

OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(4 + 2 * (NumClients + skip), 2),
Cells(4 + 2 * (NumClients + skip), NumClusters + skip)), RelationLE,
Sheets("New_Model").Range(Cells(6 + 2 * (NumClients + skip), 2), Cells(6 + 2 * (NumClients + skip),
NumClusters + skip)), Sheet:=Sheets("New_Model")

'Constraint $x_p - x_k = x + -x -$

OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(2 + NumClients + skip, 2 +
(NumClusters + skip)), Cells(2 * (NumClients + skip), 2 * (NumClusters + skip))), RelationEQ,
Sheets("New_Model").Range(Cells(2 + NumClients + skip, 2 + 2 * (NumClusters + skip)), Cells(2 *
(NumClients + skip), 3 * (NumClusters + skip))), Sheet:=Sheets("New_Model")

'Costraint $y_p - y_k = y + -y -$

OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(2 + NumClients + skip, 2 + 3 *
(NumClusters + skip)), Cells(2 * (NumClients + skip), 4 * (NumClusters + skip))), RelationEQ,
Sheets("New_Model").Range(Cells(2 + NumClients + skip, 2 + 4 * (NumClusters + skip)), Cells(2 *
(NumClients + skip), 5 * (NumClusters + skip))), Sheet:=Sheets("New_Model")

'Constraint $D_{pk} \geq D_{pk}$ constraint

OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(2, 2 + 5 * (NumClusters + skip)),
Cells(NumClients + 1, 6 * (NumClusters + skip))), RelationGE, Sheets("New_Model").Range(Cells(2 +
NumClients + skip, 2 + 5 * (NumClusters + skip)), Cells(2 * (NumClients + skip), 6 * (NumClusters +
skip))), Sheet:=Sheets("New_Model")

'Constraint lower bound of centers (x coordinate)

OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(2 + 2 * (NumClients + skip), 2 +
NumClusters + skip), Cells(2 + 2 * (NumClients + skip), 2 * (NumClusters + skip))), RelationLE,
Sheets("New_Model").Range(Cells(4 + 2 * (NumClients + skip), 2 + NumClusters + skip), Cells(4 + 2 *
(NumClients + skip), 2 * (NumClusters + skip))), Sheet:=Sheets("New_Model")

'Constraint upper bound of centers (x coordinate)

OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(4 + 2 * (NumClients + skip), 2 +
NumClusters + skip), Cells(4 + 2 * (NumClients + skip), 2 * (NumClusters + skip))), RelationLE,

Sheets("New_Model").Range(Cells(6 + 2 * (NumClients + skip), 2 + NumClusters + skip), Cells(6 + 2 * (NumClients + skip), 2 * (NumClusters + skip))), Sheet:=Sheets("New_Model")

'Constraint lower bound of centers (y coordinate)

OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(2 + 2 * (NumClients + skip), 2 + 2 * (NumClusters + skip)), Cells(2 + 2 * (NumClients + skip), 3 * (NumClusters + skip))), RelationLE, Sheets("New_Model").Range(Cells(4 + 2 * (NumClients + skip), 2 + 2 * (NumClusters + skip)), Cells(4 + 2 * (NumClients + skip), 3 * (NumClusters + skip))), Sheet:=Sheets("New_Model")

'Constraint upper bound of centers (y coordinate)

OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(4 + 2 * (NumClients + skip), 2 + 2 * (NumClusters + skip)), Cells(4 + 2 * (NumClients + skip), 3 * (NumClusters + skip))), RelationLE, Sheets("New_Model").Range(Cells(6 + 2 * (NumClients + skip), 2 + 2 * (NumClusters + skip)), Cells(6 + 2 * (NumClients + skip), 3 * (NumClusters + skip))), Sheet:=Sheets("New_Model")

'Constraint upper bound of meeting time per cluster

OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(1 + 2 * (NumClients + skip), 4 + 6 * (NumClusters + skip)), Cells(1 + 2 * (NumClients + skip), 2 + 7 * (NumClusters + skip))), RelationLE, Sheets("New_Model").Range(Cells(3 + 2 * (NumClients + skip), 4 + 6 * (NumClusters + skip)), Cells(3 + 2 * (NumClients + skip), 2 + 7 * (NumClusters + skip))), Sheet:=Sheets("New_Model")

'Constraint for x+, x-, y+, y- nonnegative numbers

OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(2, 2 + NumClusters + skip), Cells(1 + NumClients, 2 * (NumClusters + skip))), RelationGE, Sheets("New_Model").Cells(8 + 2 * (NumClients + skip), 3 + 2 * (NumClusters + skip)), Sheet:=Sheets("New_Model")

OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(2, 2 + 2 * (NumClusters + skip)), Cells(1 + NumClients, 3 * (NumClusters + skip))), RelationGE, Sheets("New_Model").Cells(8 + 2 * (NumClients + skip), 3 + 2 * (NumClusters + skip)), Sheet:=Sheets("New_Model")

OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(2, 2 + 3 * (NumClusters + skip)), Cells(1 + NumClients, 4 * (NumClusters + skip))), RelationGE, Sheets("New_Model").Cells(8 + 2 * (NumClients + skip), 3 + 2 * (NumClusters + skip)), Sheet:=Sheets("New_Model")


```
OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(2, 2 + 4 * (NumClusters + skip)),  
Cells(1 + NumClients, 5 * (NumClusters + skip))), RelationGE, Sheets("New_Model").Cells(8 + 2 *  
(NumClients + skip), 3 + 2 * (NumClusters + skip)), Sheet:=Sheets("New_Model")
```

```
OpenSolver.AddConstraint Sheets("New_Model").Range(Cells(2, 2 + 5 * (NumClusters + skip)),  
Cells(1 + NumClients, 6 * (NumClusters + skip))), RelationGE, Sheets("New_Model").Cells(8 + 2 *  
(NumClients + skip), 3 + 2 * (NumClusters + skip)), Sheet:=Sheets("New_Model")
```

```
OpenSolver.SetNonNegativity False, Sheet:=Sheets("New_Model")
```

```
OpenSolver.SetMaxTime 120, Sheet:=Sheets("New_Model")
```

```
OpenSolver.SetSolverParameters "CBC", Sheets("New_Model").Range(Cells(10 + 3 * (NumClients +  
skip), 2), Cells(11 + 3 * (NumClients + skip), 3)), Sheet:=Sheets("New_Model")
```

```
Dim Result As OpenSolverResult
```

```
Result = RunOpenSolver(False, True)
```

```
If Result = ErrorOccurred Or Result = Infeasible Then
```

```
MsgBox "El horario no pudo ser creado. Revise los clientes seleccionados y la cantidad de días  
seleccionados. Si el error prevalece, contacte a su supervisor"
```

```
Delete any worksheet in the workbook named "New_Model"
```

```
Dim WS3 As Worksheet
```

```
For Each WS3 In Worksheets
```

```
If WS3.Name = "New_Model" Then
```

```
Application.DisplayAlerts = False
```

```
Sheets("New_Model").Delete
```

```
Application.DisplayAlerts = True
```

```
End If
```

```
Next
```

```
End
```

```
End If
```

'Insert names of clients in model sheet next to assignment table (binary variables)

```
For r = 2 To 1 + NumClients
```

```
    For c = 1 To 1
```

```
        Cells(r, c).Value = Sheets("ClientesSeleccionados").Cells(r, c + 1)
```

```
    Next c
```

```
Next r
```

'Change font of worksheets

```
Sheets("ClientesSeleccionados").Activate
```

```
Range(Cells(2, 1), Cells(1 + NumClients, 1000)).Select
```

```
With Selection.Font
```

```
    .Name = "Times New Roman"
```

```
    .FontStyle = "Regular"
```

```
    .Size = 12
```

```
End With
```

```
Sheets("BaseDeDatos").Activate
```

```
Range(Cells(2, 1), Cells(1 + BaseDeDatos, 1000)).Select
```

```
With Selection.Font
```

```
    .Name = "Times New Roman"
```

```
    .FontStyle = "Regular"
```

```
    .Size = 10
```

```
End With
```

'Create assignment table in preliminary schedule (HorarioPreliminar) sheet including cluster and the names of the clients assigned to that cluster

```
Dim Counter As Integer
```

```

Counter = 1

For c = 2 To 1 + NumClusters

    For r = 3 To 2 + NumClients

        Sheets("HorarioPreliminar").Activate

        Cells(2, c).Value = "Día" & " " & (c - 1)

        Sheets("New_Model").Activate

        If Cells(r - 1, c).Value = "1" Then

            Sheets("HorarioPreliminar").Activate

            Cells(2 + Counter, c).Value = Sheets("New_Model").Cells(r - 1, 1).Value

            Cells(2 + Counter, c).Select

            Selection.Borders(xlDiagonalDown).LineStyle = xlNone

            Selection.Borders(xlDiagonalUp).LineStyle = xlNone

            With Selection.Borders(xlEdgeLeft)

                .LineStyle = xlContinuous

                .ColorIndex = 0

                .TintAndShade = 0

                .Weight = xlThin

            End With

            With Selection.Borders(xlEdgeTop)

                .LineStyle = xlContinuous

                .ColorIndex = 0

                .TintAndShade = 0

                .Weight = xlThin

            End With

```

With Selection.Borders(xlEdgeBottom)

.LineStyle = xlContinuous

.ColorIndex = 0

.TintAndShade = 0

.Weight = xlThin

End With

With Selection.Borders(xlEdgeRight)

.LineStyle = xlContinuous

.ColorIndex = 0

.TintAndShade = 0

.Weight = xlThin

End With

With Selection.Borders(xlInsideVertical)

.LineStyle = xlContinuous

.ColorIndex = 0

.TintAndShade = 0

.Weight = xlThin

End With

With Selection.Borders(xlInsideHorizontal)

.LineStyle = xlContinuous

.ColorIndex = 0

.TintAndShade = 0

.Weight = xlThin

End With

```
Counter = Counter + 1
```

```
End If
```

```
Next r
```

```
Counter = 1
```

```
Next c
```

Format for Preliminary Schedule (Horario Preliminar) Sheet including headings for client assignment table

```
Sheets("HorarioPreliminar").Activate
```

```
For c = 2 To 1 + NumClusters
```

```
Cells(2, c).Select
```

```
With Selection.Interior
```

```
.Pattern = xlSolid
```

```
.PatternColorIndex = xlAutomatic
```

```
.Color = 32768
```

```
End With
```

```
With Selection.Font
```

```
.ThemeColor = xlThemeColorDark1
```

```
End With
```

```
Selection.Font.Size = 14
```

```
Selection.Font.Bold = True
```

```
Worksheets("HorarioPreliminar").Cells.EntireColumn.AutoFit
```

```
Next c
```

```
ActiveWindow.DisplayGridlines = False
```

```
'Activate Cell A2
```

```

Sheets("ClientesSeleccionados").Activate

    Range("A2").Select

Worksheets("Configuracion").Activate

    Range("A1").Select

Worksheets("BaseDeDatos").Activate

    Range("A2").Select

Sheets("HorarioPreliminar").Activate

    Range("B3").Activate

'Delete any worksheet in the workbook named "New_Model"

Dim WS4 As Worksheet

For Each WS4 In Worksheets

    If WS4.Name = "New_Model" Then

        Application.DisplayAlerts = False

        Sheets("New_Model").Delete

        Application.DisplayAlerts = True

    End If

Next

End If

End Sub

```

Code that Checks for Errors Before Creating the Model

This code checks for errors in the input of the model. The types of errors are summarized in Table 2.

```

Sub Solver_Model()

'Turn off screen updating while performing tasks

    Application.ScreenUpdating = False

```

'Insert formulas for NumClients (Number of clients selected) and NumTiempo (Clients *for which asesores specified duration of meetings*)

```
Worksheets("Configuracion").Activate
```

```
Cells(10, 3).Formula = "=Counta(ClientesSeleccionados!" & Range("A:A").Address & ")-1"
```

```
Cells(11, 3).Formula = "=Counta(ClientesSeleccionados!" & Range("E:E").Address & ")-1"
```

'Determine NumClients

```
Dim NumClients As Integer
```

```
NumClients = Sheets("Configuracion").Cells(10, 3)
```

'Determine NumTiempo

```
Dim NumTiempo As Integer
```

```
NumTiempo = Sheets("Configuracion").Cells(11, 3)
```

'Apply conditional formatting to first column of clientes seleccionados to show the duplicates in the selected clients

```
Worksheets("ClientesSeleccionados").Activate
```

```
Range(Cells(2, 1), Cells(NumClients + 1, 1)).Select
```

```
Selection.FormatConditions.AddUniqueValues
```

```
Selection.FormatConditions(Selection.FormatConditions.Count).SetFirstPriority
```

```
Selection.FormatConditions(1).DupeUnique = xlDuplicate
```

```
With Selection.FormatConditions(1).Font
```

```
.Color = -16383844
```

```
.TintAndShade = 0
```

```
End With
```

```
With Selection.FormatConditions(1).Interior
```

```
.PatternColorIndex = xlAutomatic
```

```
.Color = 13551615
```

.TintAndShade = 0

End With

Selection.FormatConditions(1).StopIfTrue = False

'Checks for duplicates in another tab called "CheckDuplicates" by copying and pasting into the new tab, removing duplicates in that list, and comparing the amount of rows

Sheets("ClientesSeleccionados").Activate

Range(Cells(2, 1), Cells(1 + NumClients, 1)).Select

Selection.Copy

Sheets.Add.Name = "CheckDuplicates"

Sheets("CheckDuplicates").Activate

Range("A1").PasteSpecial

Columns("A:A").Select

Application.CutCopyMode = False

ActiveSheet.Columns("A:A").RemoveDuplicates Columns:=1, Header:=xlNo

Sheets("Configuración").Activate

Cells(12, 3).Formula = "=Counta(CheckDuplicates!" & Range("A:A").Address & ")"

'Determine Duplicates

Dim Duplicates As Integer

Duplicates = Sheets("Configuracion").Cells(12, 3)

'If Statement to check if the number of clients with duplicates removed is less than the number in "ClientesSeleccionados" tab

If Duplicates < NumClients Then

'Delete Worksheet called "CheckDuplicates" and showing message box for eliminating duplicates

Dim WS4 As Worksheet

For Each WS4 In Worksheets

If WS4.Name = "CheckDuplicates" Then

Application.DisplayAlerts = False

Sheets("CheckDuplicates").Delete

Application.DisplayAlerts = True

End If

Next

Worksheets("ClientesSeleccionados").Activate

MsgBox "Hay clientes repetidos. Elimine uno de los repetidos resaltados en rojo"

ElseIf NumTiempo < NumClients Then

Delete Worksheet called "CheckDuplicates" and show message box for inserting meeting time for all selected clients

Dim WS5 As Worksheet

For Each WS5 In Worksheets

If WS5.Name = "CheckDuplicates" Then

Application.DisplayAlerts = False

Sheets("CheckDuplicates").Delete

Application.DisplayAlerts = True

End If

Next

Worksheets("ClientesSeleccionados").Activate

MsgBox "Inserte tiempo de duracion de reunion para todos los clientes seleccionados"

Else

Delete Worksheet called "CheckDuplicates"

Dim WS6 As Worksheet

```

For Each WS6 In Worksheets

    If WS6.Name = "CheckDuplicates" Then

        Application.DisplayAlerts = False

        Sheets("CheckDuplicates").Delete

        Application.DisplayAlerts = True

    End If

Next

```

Remove conditional formatting

```

Worksheets("ClientesSeleccionados").Activate

Range("A:A").FormatConditions.Delete

Range("A2").Select

```

Show userform that asks for the number of days to schedule. See Inserte User form for the code of the rest of the tool

```

    Inserte.Show

End If

End Sub

```

Macros Used by the Tool

This code was used for the user forms included in the excel tool. These are shown in Figure 11.

```

Sub Abrir()

    Inserte.Show

End Sub

Sub Minimo()

    EditarMinimo.Show

End Sub

Sub Maximo()

```

```

    EditarMaximo.Show

End Sub

Sub MaxTiempo()

    EditarMaxTiempo.Show

End Sub

Sub Show_UserForm()

    Lista.Show

End Sub

Sub Nombres()

'Turn off screen updating while performing tasks

    Application.ScreenUpdating = False

'Activate "Configuracion" tab

    Worksheets("Configuracion").Activate

'Insert formulas to count the number of selected clients in "Clientes Seleccionados" and number of clients
in Base De Datos

    Cells(10, 3).Formula = "=Counta(ClientesSeleccionados!" & Range("A:A").Address & ")-1"

    Cells(9, 3).Formula = "=Counta(BaseDeDatos!" & Range("A:A").Address & ")-1"

'Determine NumClients and BasDeDatos

    Dim NumClients As Integer

    NumClients = Sheets("Configuracion").Cells(10, 3)

    Dim BaseDeDatos As Integer

    BaseDeDatos = Sheets("Configuracion").Cells(9, 3)

'Check if an ID number is not in BaseDeDatos and return message

    Worksheets("ClientesSeleccionados").Activate

```

```

For r = 2 To 1 + NumClients

    Cells(r, 2).Formula = "=VLOOKUP(" & Cells(r, 1).Address & ", BaseDeDatos!" & Range(Cells(2,
1), Cells(BaseDeDatos + 1, 4)).Address & ", ""2"", FALSE)"

    If IsError(Cells(r, 2)) Then

        MsgBox "Una de las cédulas de identidad en la columna A no se encuentra en la base de datos.
Revise si la cédula de identidad esta correcta o agregue la informacion del cliente a la base de datos."

    End If

Next r

'Font for Clientes Seleccionados

Sheets("ClientesSeleccionados").Activate

Range(Cells(2, 1), Cells(1 + NumClients, 1000)).Select

With Selection.Font

    .Name = "Times New Roman"

    .FontStyle = "Regular"

    .Size = 12

End With

Sheets("BaseDeDatos").Activate

Range(Cells(2, 1), Cells(1 + BaseDeDatos, 1000)).Select

With Selection.Font

    .Name = "Times New Roman"

    .FontStyle = "Regular"

    .Size = 10

End With

'Activate Cells "A2" in "Clientes Seleccionados" and "BaseDeDatos"

Worksheets("BaseDeDatos").Activate

```

```

    Range("A2").Select

    Sheets("ClientesSeleccionados").Activate

    Range("A2").Select

End Sub

Sub Reiniciar()

'Turn off screen updating while performing tasks

    Application.ScreenUpdating = False

'Activate Worksheet and select columns "A:E"

    Worksheets("ClientesSeleccionados").Activate

    Range("A2:E2").Select

    Range(Selection, Selection.End(xlToRight)).Select

    Range(Selection, Selection.End(xlDown)).Select

    Selection.ClearContents

    Range("A2").Select

    Worksheets("BaseDeDatos").Activate

    Range("A2").Select

    Worksheets("ClientesSeleccionados").Activate

End Sub

```

Code Used in all Userforms

Userform Used to Determine the Maximum Amount of Meetings per Day

```

Private Sub OkMaximo_Click()

    Worksheets("Configuracion").Unprotect

    Application.ScreenUpdating = False

    If TextBox1.Value = "" Then

```

```

    MsgBox ("Necesita determinar el numero de dias")

    ElseIf IsNumeric(TextBox1) Then

        Worksheets("Configuracion").Range("C5").Value = TextBox1.Text

    End If

    Cells.Select

    Selection.Locked = True

    Selection.FormulaHidden = True

    ActiveSheet.Protect

    Worksheets("Configuracion").Protect

    Worksheets("Configuracion").Activate

    Range("C4").Select

    Unload Me

End Sub

Private Sub TextBox1_KeyPress(ByVal KeyAscii As MSForms.ReturnInteger)

    If (KeyAscii > 47 And KeyAscii < 58) Then

        KeyAscii = KeyAscii

    Else

        KeyAscii = 0

        MsgBox "Solo puede insertar numeros"

    End If

End Sub

Private Sub UserForm_Initialize()

    Application.ScreenUpdating = False

    With EditarMaximo

```

```

        .StartupPosition = 0

        .Top = 200

        .Left = 375

    End With

    Application.ScreenUpdating = True

End Sub

Private Sub OkMaxTiempo_Click()

    Worksheets("Configuracion").Unprotect

    Application.ScreenUpdating = False

    If TextBox1.Value = "" Then

        MsgBox ("Necesita determinar el numero de dias")

    ElseIf IsNumeric(TextBox1) Then

        Worksheets("Configuracion").Range("C6").Value = TextBox1.Text

    End If

    Cells.Select

    Selection.Locked = True

    Selection.FormulaHidden = True

    ActiveSheet.Protect

    Worksheets("Configuracion").Protect

    Worksheets("Configuracion").Activate

    Range("C4").Select

    Unload Me

End Sub

Private Sub TextBox1_KeyPress(ByVal KeyAscii As MSForms.ReturnInteger)

```

```

If (KeyAscii > 47 And KeyAscii < 58) Then

    KeyAscii = KeyAscii

Else

    KeyAscii = 0

    MsgBox "Solo puede insertar numeros"

End If

End Sub

Userform Used to Determine the Maximum Total Meeting Time per Day
Private Sub OkMaxTiempo_Click()

    Worksheets("Configuracion").Unprotect

    Application.ScreenUpdating = False

    If TextBox1.Value = "" Then

        MsgBox ("Necesita determinar el numero de dias")

    ElseIf IsNumeric(TextBox1) Then

        Worksheets("Configuracion").Range("C6").Value = TextBox1.Text

    End If

    Cells.Select

    Selection.Locked = True

    Selection.FormulaHidden = True

    ActiveSheet.Protect

    Worksheets("Configuracion").Protect

    Worksheets("Configuracion").Activate

    Range("C4").Select

    Unload Me

```


End Sub

Private Sub TextBox1_KeyPress(ByVal KeyAscii As MSForms.ReturnInteger)

 If (KeyAscii > 47 And KeyAscii < 58) Then

 KeyAscii = KeyAscii

 Else

 KeyAscii = 0

 MsgBox "Solo puede insertar numeros"

 End If

End Sub

Private Sub UserForm_Initialize()

 Application.ScreenUpdating = False

 With EditarMaxTiempo

 .StartUpPosition = 0

 .Top = 200

 .Left = 375

 End With

 Application.ScreenUpdating = True

End Sub

Userform Used to Determine the Minimum Amount of Meetings per Day

Private Sub OkMinimo_Click()

 Worksheets("Configuracion").Unprotect

 Application.ScreenUpdating = False

 If TextBox1.Value = "" Then

 MsgBox ("Necesita determinar el numero de dias")

```

ElseIf IsNumeric(TextBox1) Then

    Worksheets("Configuracion").Range("C4").Value = TextBox1.Text

End If

Cells.Select

Selection.Locked = True

Selection.FormulaHidden = True

ActiveSheet.Protect

Worksheets("Configuracion").Protect

Worksheets("Configuracion").Activate

Range("C4").Select

Unload Me

End Sub

Private Sub TextBox1_KeyPress(ByVal KeyAscii As MSForms.ReturnInteger)

    If (KeyAscii > 47 And KeyAscii < 58) Then

        KeyAscii = KeyAscii

    Else

        KeyAscii = 0

        MsgBox "Solo puede insertar numeros"

    End If

End Sub

Private Sub UserForm_Initialize()

    Application.ScreenUpdating = False

    With EditarMinimo

        .StartupPosition = 0

```

```

.Top = 200

.Left = 375

End With

Application.ScreenUpdating = True

End Sub

Private Sub Agregar_Click()

'Determine BaseDeDatos and LastRow

Dim BaseDeDatos As Integer

BaseDeDatos = Sheets("Configuracion").Cells(9, 3)

Dim LastRow As Object

'Checks whether the worker filled out both fields were filled out

If Cedula.Value = "" Or Tiempo.Value = "" Then

MsgBox ("Necesita llenar informacion para ambos")

End If

'Checks whether the ID of the client inserted exists in the database

Set LastRow = Worksheets("ClientesSeleccionados").Range("a65536").End(xlUp)

LastRow.Offset(1, 0).Value = Cedula.Text

LastRow.Offset(1, 4).Value = Tiempo.Text

LastRow.Offset(1, 1).Formula = "=IfError(VLOOKUP(" & LastRow.Offset(1, 0).Address & ",
BaseDeDatos!" & Range(Cells(2, 1), Cells(BaseDeDatos + 1, 4)).Address & ", ""2"", FALSE), ""No Existe
Cliente"")"

If LastRow.Offset(1, 1).Value = "No Existe Cliente" Then

MsgBox "La cedula de identidad que agrego no se encuentra en la base de datos. Revise si esta
correcta o agregue la informacion del cliente a la base de datos."

LastRow.Offset(1, 1).Select

```

```
Selection.FormatConditions.Add Type:=xlTextString, String:="No existe cliente",  
TextOperator:=xlContains
```

```
Selection.FormatConditions(Selection.FormatConditions.Count).SetFirstPriority
```

```
With Selection.FormatConditions(1).Font
```

```
.Color = -16383844
```

```
.TintAndShade = 0
```

```
End With
```

```
With Selection.FormatConditions(1).Interior
```

```
.PatternColorIndex = xlAutomatic
```

```
.Color = 13551615
```

```
.TintAndShade = 0
```

```
End With
```

```
Selection.FormatConditions(1).StopIfTrue = False
```

```
End If
```

```
End Sub
```

Userform Used to Add Clients Manually

```
Private Sub Cedula_KeyPress(ByVal KeyAscii As MSForms.ReturnInteger)
```

'Checks if what the worker entered into the ID are numbers and returns message if they are not numbers

```
If (KeyAscii > 47 And KeyAscii < 58) Then
```

```
KeyAscii = KeyAscii
```

```
Else
```

```
KeyAscii = 0
```

```
MsgBox "Solo puede insertar numeros"
```

```
End If
```

```
End Sub
```

```
Private Sub Label2_Click()
```

```
End Sub
```

```
Private Sub Ok2_Click()
```

```
    Unload Me
```

```
End Sub
```

```
Private Sub Tiempo_KeyPress(ByVal KeyAscii As MSForms.ReturnInteger)
```

```
'Checks if what the worker entered into the duration of meetings entered are numbers and returns message  
if they are not numbers
```

```
    If (KeyAscii > 47 And KeyAscii < 58) Then
```

```
        KeyAscii = KeyAscii
```

```
    Else
```

```
        KeyAscii = 0
```

```
        MsgBox "Solo puede insertar numeros"
```

```
    End If
```

```
End Sub
```

Appendix C: Records of Schedules Followed by Asesores

| Office: Santani - Asesora: Luci Gonzalez | | | | | |
|--|-----------|------------------------|-----------|-----------|-------------------------------|
| Date | Client ID | Full Name | Latitude | Longitude | Duration of Meeting (Minutes) |
| 01/04/16 | 2662300 | Mariana Saldivar | -24.81347 | -56.52333 | 100 |
| 04/04/16 | 3006733 | Sonia Gimenez | -24.68407 | -56.39026 | 100 |
| 05/04/16 | 2959833 | Inocencia Insaurrealde | -24.191 | -56.60581 | 100 |
| 05/04/16 | 3677880 | Pelagia Martinez | -24.30091 | -56.42356 | 180 |
| 06/04/16 | 5237440 | Liza Franco | -24.47424 | -56.11873 | 180 |
| 06/04/16 | 2112120 | Cresencia Esquivel | -24.68304 | -56.39293 | 60 |
| 07/04/16 | 2426425 | Daniela Franco | -24.97351 | -56.30721 | 120 |
| 08/04/16 | 6854064 | Nilsa Mancuello | -24.65923 | -56.43802 | 120 |
| 11/04/16 | 5707903 | Aline Duarte | -24.81529 | -56.72881 | 100 |
| 11/04/16 | 1315215 | Maria Estigarribia | -24.81632 | -56.73366 | 100 |

| Office: Ybycui - Asesora: Nancy Jimenez | | | | | |
|---|-----------|-----------------------------|------------|----------------|-------------------------------|
| Date | Client ID | Full Name | Latitude | Longitude | Duration of Meeting (Minutes) |
| 05/04/2016 | 4652381 | Celia Gonzalez Arce | -25.933868 | - 57.166632 | 150 |
| 06/04/2016 | 5096363 | Luisa Otazú Ranoni | -26.01547 | - 56.976993 | 240 |
| 06/04/2016 | 4344368 | Fanny Emilse Perez Saavedra | -25.919541 | - 57.091409 | 90 |
| 06/04/2016 | 2314700 | Georginia Torres de Cabañas | -25.878819 | - 57.073558 | 240 |
| 07/04/2016 | 2183648 | Juana De Jesús Olazar | -26.221286 | - 56.756084 | 180 |

| Office: Luque - Asesora: Monserrat Urbietta | | | | | |
|---|-----------|--------------------|------------|------------|-------------------------------|
| Date | Client ID | Full Name | Latitude | Longitude | Duration of Meeting (Minutes) |
| 04/04/16 | 1742857 | Damasia Avalos | -25.306954 | -57.418549 | 90 |
| 04/04/16 | 3547775 | Josefina Rios | -25.268936 | -57.491822 | 90 |
| 04/04/16 | 5108410 | Noemi Quiñonez | -25.294604 | -57.521281 | 90 |
| 05/04/16 | 820386 | Jacinta Ojeda | -25.294604 | -57.521281 | 120 |
| 05/05/16 | 905046 | Lucia Rodriguez | -25.217808 | -57.442108 | 90 |
| 05/05/16 | 3880475 | Cristina Rodriguez | -25.304886 | -57.43138 | 120 |
| 06/04/16 | 2008632 | Graciela Torres | -25.314244 | -57.389324 | 90 |
| 06/04/16 | 1478965 | Patricia Palma | -25.293973 | -57.417941 | 60 |
| 07/04/16 | 3956114 | Julia Cabrera | -25.307456 | -57.461223 | 30 |
| 07/04/16 | 889165 | Teresa Martinez | -25.274551 | -57.506792 | 90 |
| 08/04/16 | 1103032 | Dora Rivas | -25.377237 | -57.308182 | 90 |
| 08/04/16 | 1059030 | Andresa Britez | -25.287521 | -57.521024 | 150 |
| 08/04/16 | 1579341 | Isabel Sanchez | -25.303753 | -57.415289 | 90 |

| Office: Ciudad del Este - Asesora: Sonia Ferreira | | | | | |
|---|-----------|-----------------------|-----------|-----------|-------------------------------|
| Date | Client ID | Full Name | Latitude | Longitude | Duration of Meeting (Minutes) |
| 4/4/2016 | 3296240 | Eresmilda Figueredo | -25.51279 | -54.65972 | 60 |
| 4/7/2016 | 4245050 | Ramona Bareiro | -25.54273 | -54.61149 | 60 |
| 4/8/2016 | 819860 | Sara Rosso | -25.53375 | -54.6115 | 60 |
| 4/8/2016 | 2052108 | Maria teresa Carbario | -25.54529 | -54.60398 | 60 |

| Office: Asuncion - Asesora: Andrea Gianina Burgos Pereira | | | | | |
|---|-----------|---------------------|------------|------------|-------------------------------|
| Date | Client ID | Full Name | Latitude | Longitude | Duration of Meeting (Minutes) |
| 04/04/16 | 538863 | Maria Antonia Sosa | -25.396222 | -57.544898 | 80 |
| 04/04/16 | 793390 | Maria Ines Bordon | -25.319238 | -57.608904 | 80 |
| 05/05/16 | 4345480 | Mirian Garcia | -25.400697 | -57.571836 | 50 |
| 06/04/16 | 4798853 | Katia Maldonado | -25.349034 | -57.607852 | 50 |
| 06/04/16 | 3819235 | Liz Paola Areca | -25.362467 | -57.606822 | 40 |
| 06/04/16 | 1948600 | Zunilda Paredes | -25.313668 | -57.639803 | 80 |
| 07/04/16 | 3559225 | Luz Gimenez | -25.397841 | -57.564426 | 30 |
| 07/04/16 | 4345480 | Mirian Garcia | -25.400697 | -57.571836 | 30 |
| 08/04/16 | 4938831 | Liz Castro | -25.361735 | -57.606559 | 30 |
| 08/04/16 | 1347396 | Nilvia Ortiz | -25.335125 | -57.600347 | 30 |
| 08/04/16 | 954731 | Maria Elena Vazquez | -25.360189 | -57.61445 | 60 |

| Office: San Lorenzo - Asesora: Lourdes Romina Molinas Ferreira | | | | | |
|--|-----------|-----------------------------|------------|------------|-------------------------------|
| Date | Client ID | Full Name | Latitude | Longitude | Duration of Meeting (Minutes) |
| 04/04/16 | 1243684 | Perla Garcia | -25.459906 | -57.469362 | 80 |
| 04/04/16 | 873543 | Sinforiana Insfran | -25.410088 | -57.469768 | 80 |
| 05/05/16 | 1587277 | Mirta Elena Prantte | -25.391237 | -57.490136 | 60 |
| 05/05/16 | 4288147 | Lucia Salinas | -25.408179 | -57.483146 | 60 |
| 06/04/16 | 3893136 | Antonia Alonso | -25.403293 | -57.516262 | 20 |
| 07/04/16 | 1843377 | Silvina Samaniego de Rodas | -25.395405 | -57.519148 | 60 |
| 07/04/16 | 753197 | Reinalda Isabel Aguilera | -25.305351 | -57.506477 | 60 |
| 07/04/16 | 3260449 | Lina Estela Ferreira Prieto | -25.288984 | -57.502334 | 20 |
| 07/04/16 | 995502 | Flora Aguilar de Gonzalez | -25.490212 | -57.451749 | 20 |
| 08/04/16 | 3264065 | Alodia Villalba Mora | -25.4962 | -57.452642 | 60 |

| Office: Concepcion - Asesora: Alba Ruiz | | | | | |
|---|-----------|------------------------|----------|------------|-------------------------------|
| Date | Client ID | Full Name | Latitude | Longitude | Duration of Meeting (Minutes) |
| 4/4/2016 | 3857622 | Juliana Avalos | -23.3861 | -57.437421 | 180 |
| 4/4/2016 | 4568001 | Maria Magdana Sanabria | -23.3937 | -57.456657 | 60 |
| 4/4/2016 | 1257125 | Wilfrida Arce | -23.3907 | -57.42705 | 60 |
| 4/8/2016 | 3857622 | Juliana Avalos | -23.3861 | -57.437421 | 60 |

| Office: Coronel Oviedo - Asesora: Mirian Torres Rojas | | | | | |
|---|-----------|---------------|------------|-----------|-------------------------------|
| Date | Client ID | Full Name | Latitude | Longitude | Duration of Meeting (Minutes) |
| 4/4/2016 | 7,158,288 | Fatima Valdez | -25.457424 | -56.467 | 60 |
| 4/5/2016 | 3,734,017 | Zulma Marin | -25.438693 | -56.4185 | 30 |
| 4/5/2016 | 7,201,150 | Liz Martinez | -25.460343 | -56.445 | 40 |
| 4/5/2016 | 5,472,546 | Ada Flor | -25.443569 | -56.4324 | 40 |
| 4/5/2016 | 4,583,128 | Juana Sosa | -25.442937 | -56.4303 | 40 |

| Office: Paraguari - Asesora: Maria Belen Alcaraz | | | | | |
|--|-----------|-------------------|-----------|-----------|-------------------------------|
| Date | Client ID | Full Name | Latitude | Longitude | Duration of Meeting (Minutes) |
| 4/5/2016 | 4426766 | Myrian Guanes | -25.51331 | -57.31226 | 90 |
| 4/5/2016 | 2106503 | Germana Moreno | -25.60858 | -57.26564 | 90 |
| 4/6/2016 | 5047807 | Carmelina Lezcano | -25.52884 | -57.26999 | 90 |
| 4/6/2016 | 2013135 | Vilma Giminez | -25.55635 | -57.06152 | 90 |

| Office: Encarnacion - Asesora: Gladys Ojeda | | | | | |
|---|-----------|-------------------------|------------|------------|-------------------------------|
| Date | Client ID | Full Name | Latitude | Longitude | Duration of Meeting (Minutes) |
| 04/04/16 | 2979280 | Delia Ruiz Diaz | -27.218531 | -55.801485 | 60 |
| 06/04/16 | 1967206 | Lidia Bravo | -27.050189 | -55.559472 | 60 |
| 06/04/16 | 4112828 | Soraida Duart | -27.040884 | -55.575585 | 60 |
| 07/04/16 | 5922734 | Maria Soledad figueredo | -27.234785 | -55.810086 | 90 |
| 07/04/16 | 1,566,302 | Fidelina Alcaraz | -27.360673 | -55.762059 | 90 |